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# BIBLIOGRAPHY
# OF
# VIBRATION AND FLUTTER
# OF
# AIRCRAFT WINGS AND CONTROL SURFACES

4036 H.15

Compiled with the cooperation of

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This bibliography has been prepared by
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Project 165-97-6038

1937

# FOREWORD

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This bibliography on "Flutter and Vibration", with particular reference to aircraft structure, has been prepared by the Works Progress Administration under the supervision of Dr. Alexander Klemin and Professor Frederick K. Teichmann of New York University.

The bibliography covers not only the specific work in flutter and vibration of aircraft but also deals with the general instrumentation of vibration research. Work on similar lines conducted in allied industries has been fully covered and is likely to shed much light on the problems of aeronautical vibration. The bibliography has been divided into a number of parts to facilitate the binding of references and appropriate parts of the general subject. Endeavor has been made to cover both European and American publications.

Persons and organizations may apply for copies by writing to

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# FLUTTER AND BUFFETING OF WINGS AND CONTROL SURFACES

Lanchester, F. W. Torsional Vibrations of the Tail of an Aeroplane. British A.R.C., R. & M. No. 276, July 1916. p. 458-460. (figures)

Analysis of difficulty experienced in a plane. At certain critical speeds of flight, a tail wobble is set up involving heavy torsional stresses on the fuselage, the type of vibration being an angular oscillation. Suggestions for correction based on deductions.

Chu, L. Damping Coefficients Due to Tail Surfaces in Aircraft. N.A.C.A., Tech. Rep. No. 136, 1922. p. 111-124. (figures, tables)

Experiments to compare the damping coefficients of an airfoil as calculated from a knowledge of the static characteristics of the section with those obtained experimentally with an oscillator.

Munk, M. M. The Tail Plane. N.A.C.A., Tech. Rep. No. 133, 1922. p. 53-87. (figures)

Calculation of the equilibrium, statical stability and damping of the tail plane. Gives a simplified theory of longitudinal stability for the purpose of obtaining one definite coefficient characteristic of the effect of the tail plane. Brief discussion of oscillations. Designer has to avoid a certain critical length of the fuselage, which gives rise to periodical oscillations of the airplane. Oscillations and vibrations tend to increase structural stresses. The tail plane is more subject to them than the wings.

______________ The Accident to the Gloster II. Flight, v. 17, no. 25, June 18, 1925. p. 374.

Pilot noticed the tail of his machine flutter as the airplane approached the ground. He switched off and landed, but due to a speed of 200 m.p.h. the tires were ripped off, then the wheels, and finally the whole undercarriage collapsed. Theory as to the cause of the accident: the impulses of the slip-stream on the tail had a period corresponding to the period of the tail itself, and that it was something of this sort that gave rise to the tail flutter.

________________ Accidents to Aeroplanes Involving Flutter of the Wings. British A.R.C., R. & M. No. 1041, Dec. 1925. 19 p. (appendices, figures)

Report refers to an early type of aircraft no longer used in the Royal Air Force. Appendix I - Brief description of each of five accidents of the flutter nature with a general statement of the results of examinations of the machines after the occurrences. Appendix II - Discussion of the theory of wing flutter. Appendix III - Discussion of vibration of structure. Appendix IV - Discussion of experiments of small model spars. Appendix V - Report of flutter tests in flight on a modified aeroplane. Preventive measures suggested.

Blenk, H. and Liebers, F. Gekoppelte Torsions-und Biegungsschwingungen von Tragflügeln. Z.F.M., v. 16, no. 23, Dec. 14, 1925. p. 479-486. (figures, equations)

Deals with the torsional oscillations of a cantilever, two-sparred wing. Oscillation is around an elastic axis and the two wing spars have torsional and flexural stresses. Critical velocity found. Mass distribution studied in connection with the elastic axis, etc.

Blenk, H. Gekoppelte Torsions-und Biegungsschwingungen von Tragflügeln. Second Inter. Cong. Appl. Mech.-Proc., Sept. 1926. p. 231-239. (figures, references)

Determination of the critical speed of cantilever wings with two degrees of freedom. Torsional and flexural vibrations studied.

Frazer, R. A. An Investigation on Wing Flutter. British A.R.C., R. & M. No. 1042, Feb. 1926. 22 p. (figures, tables, references)

Paper extends earlier theoretical work on flutter. Dynamical equations obtained on a more exact basis than has been considered expedient hitherto. Motion is analyzed in some detail, with reference to the illustrative case of a particular biplane.

Raab, A. Flügelschwingungen an freitragenden Eindeckern. Z.F.M., v. 17, no. 7, April 14, 1926. p. 146-147.

Wings of monoplanes with little or no external bracing have been found to flutter, especially when subjected to high speed or to gusts. If the flier tries to land rapidly, without knowing the cause of the flutter, the condition becomes critical resulting in complete collapse. Wings of internally trussed monoplanes should be made of light and strong materials without too heavy connecting pieces.

__________ Concerning Wing Flutter. Aeroplane, v. 32, no. 8, Feb. 23, 1927. p. 208-210. (figure)

A non-technical article which defines flutter and compares it with self-warping. The cause of wing flutter described: how it is provoked, conditions which determine whether flutter shall occur, and cures.

Bailey, N. R. Progress Report on the Study of Torsion on Wing Framework. A.C.I.C., v. 6, no. 584, March 1, 1927. 49 p. Materiel Division Report, Serial No. 2712. (appendix, figures, tables)

Part I - Experimental study of ways and means of furnishing torsional rigidity demanded by aerodynamic considerations.

Part II- Theoretical study to discover definite laws, according to which a wing frame deflects under torsional loads, that can be relied upon for use in aerodynamic solution of the cause of wing flutter, and which can be used for designing a wing to give stable deflections. Recommendations made for further study.

Blenk, H. Gegenwartsfragen der Aerodynamik. Z.V.D.I., v. 72, no. 40, Oct. 6, 1928. p. 1395-1401. (figures, bibliography)

Causes of structural resonance and wing flutter. During recent gliding experiments, many examples of wing and tail flutter were studied and the various methods of eliminating them are described.

Blenk, H. and Liebers, F. Flügelschwingungen von freitragenden Eindeckern. L.F.F., v. 1, no. 1, Jan. 3, 1928. p. 1-17. (figures, tables, references)
Also D.V.L. Jahrbuch 1928, Rep. No. 80. p. 63-79.

Theory developed of torsional and flexural coupled oscillations which leads to various equations of difficult solution. Experiments performed on full-scale wings in order to find out the elastic constants. Three types of wings used. The critical calculated speeds for these wings above the normal flying speed considered. One wing gave, in its critical calculated speed, a few mile-hours above the maximum horizontal velocity. The critical speed of the other two wings were 60% above.

Duncan, W. J. and Frazer, R. A. A Brief Survey of Wing Flutter with an Abstract of Design Recommendations. British A.R.C., R. & M. No. 1177, Aug. 1928. 31 p. (appendix, tables, references)

Part I - Non-mathematical survey of the problem of wing flutter (work hitherto completed). Concise review for general use. List of design recommendations.

Part II- Wind tunnel experiments to test the efficacy of the recommendations. List of references appended on wing flutter and cognate matters.

Duncan, W. J. and Frazer, R. A. Conditions for the Prevention of Flexural Torsional Flutter of an Elastic Wing. British A.R.C., R. & M. No. 1217, Dec. 1928. 16 p. (appendix)

Theoretical analysis of the conditions for the prevention of flexural torsional flutter of an elastic wing. Conclusions strongly support the deductions regarding stability of the flexural-torsional motion of a wing from the semi-rigid theory (R. & M. No. 1155). General method for discussion of stability developed. Treatment is extended to stayed wings of a certain type.

Frazer, R. A. and Duncan, W. J. The Flutter of Aeroplane Wings. British A.R.C., R. & M. No. 1155, Aug. 1928. 218 p. (appendices, figures, tables, references)

Theoretical and experimental account of work hitherto completed on the subject of wing flutter with special reference to monoplanes, on the assumption of an immobile fuselage. Design recommendations given for the prevention of wing flutter.

Gates, S. B. The Torsion-Flexure Oscillations of a System of Two Connected Beams. Phil. Mag., S. 7, v. 5, no. 27, Jan. 1928. p. 97-112. (figure, equations, references)

This work in its original form was a contribution to the theory of wing flutter. A type of elastic hydrodynamic problem is presented which assumes some importance in aeronautics and has not hitherto received much study. One important consequence of the retention of the fluid reaction is that the independence of the flexural and torsional oscillations is destroyed. The author investigates this condition mathematically and works out equations which determine the first appearance of instability.

Glauert, H. The Lift and Pitching Moment of an Aerofoil Due to a Uniform Angular Velocity of Pitch. British A.R.C., R. & M. No. 1216, Nov. 1928. 9 p. (figures)

Pitching moment may be an important factor in the problem of wing flutter, therefore it is desirable to obtain a theoretical estimate of this moment. The analysis is confined to the condition of uniform angular velocity. This analysis provides theoretical estimates of lift and pitching moment of an aerofoil section in two dimensional motion and of a rectangular aerofoil of any aspect ratio.

Greene, C. F. An Introduction to the Problem of Wing Flutter. A.S.M.E.-Trans., v. 50, AER 50-10, 1928. p. 9-15. (figures, references, discussion)

After defining wing flutter and analyzing the evidence accumulated as to the conditions under which it occurs, particulars are given of a study of the torsional oscillations of an airfoil and of the position of the elastic axis and location of the center of mass of an airplane wing. Discussion of the aerodynamic considerations involved in the problem. Brief discussion of the field of future investigation. Purpose of the paper is to promote a discussion as to rational methods of employing such data as are now, or may be, on hand, with a view to formulating a sound basis for future design procedure.

Perring, W. G. A. Wing Flutter Experiments Upon a Model of a Single Seater Biplane. British A.R.C., R. & M. No. 1197, Nov. 1928. 20 p. (appendix, figures, tables)

Wind tunnel experiments were made upon a model of reduced elasticity to determine the critical speeds under various conditions. The model represented to 1/3 scale the port wing structure of a single seater biplane. Full scale and model tests were made to check the flexural and torsional stiffness of both upper and lower planes, and of a complete wing unit. Results are in good accord with the dimensional theory. Tests show the possibility of reproducing wing flutter in the wind tunnel with models of reduced rigidity, so far as these relate to planes of wooden construction.

Thoret, - Un Record de Battements D'Ailerons. L'Aerophile, v. 36, no. 21-22, Nov. 1928. p. 333-334.

Considerable wing and aileron vibrations were noted on a French light aeroplane when flying at high speed in "bumpy" air. By throttling down and by a short glide, the vibrations could be damped out. The vibrations were traced to a slackness of the aileron hinge.

Younger, J. E. Wing Flutter Investigation on Brady's Wind Tunnel Model. A.C.I.C., v. 7, no. 608, Feb. 1, 1928. 3 p. Materiel Division Report, Serial No. 2826. (figures)

Brief investigation of the practicability of studying wing flutter by wind tunnel model tests. A number of interesting and significant points were observed in the behavior of the wing and tentative conclusions were drawn concerning the nature and cause of one type of wing flutter. A mode of procedure is suggested for a systematic investigation of the problem whether by model or full scale tests.

Zahm, A. F. and Bear, R. M. A Study of Wing Flutter. N.A.C.A., Tech. Rep. No. 285, 1928. p. 107-134. (figures, tables, equations, references)

Part I - Vibration of MO-1 Tail Plane and Other Airfoils. Chiefly a description of tests made in February 1925, and later, for the Bureau of Aeronautics in the 4 x 4 wind tunnel of the C & R Aerodynamical Lab., Washington Navy Yard. Conclusions drawn as to the cause and cure of aerodynamic wing vibrations.

Part II- Theory of Oscillations of an Airfoil in Pitch and Roll. Derives stability criteria for wing vibrations in pitch and roll and gives design rules to obviate instability.

Part III - Design of Spars for Equal Flexure. As the title implies, information is given as to how to design spars to flex equally under a given loading when given the wing plan and profile.

____________ Study of Wing Flutter. Part I - Test of Apparatus and Discussion of Procedure. A.C.I.C., v. 7, no. 635, Sept. 15, 1929. 16 p. Air Corps Tech. Rep. No. 3002. (appendix, figures)

Presents results obtained in the investigation of a particular method of determining under what conditions destructive oscillations are set up in internally braced wings. Discussion of test apparatus and procedure developed to determine the causes and prevention of wing flutter. Description of wing flutter experiments and difficulties encountered. Appendix contains theoretical discussion of the natural period of vibration of a wing, also experimental verification of the theory.

____________ Rigidity and Flexibility of Airplane Structures. A.C.I.C., v. 7, no. 642, Oct. 1, 1929. 3 p. Air Corps Tech. Rep. No. 3074.

Calculation of rigidity requirements to preclude flutter and vibration. It was found that rigidity predictions may, in most cases, be based on strength requirements.

____________ Mechanische Schwingungen in der Luftfahrttechnik. Z.V.D.I., v. 73, no. 41, Oct. 12, 1929. p. 1487.

A summary of a symposium of papers on mechanical vibrations, particularly on vibration of wings in flight, vibrations of airscrews, measurement of noise, vibration of fuel in pipe lines, and the effect of vibration on fatigue limits and ultimate strength.

Bolas, H. Tail Flutter - A New Theory. Aircraft Engineering, v. 1, no. 1, March 1929. p. 16-21. (figures)

Discusses in detail the structural instability of tail planes at high speed. Theoretical treatment is an endeavor to calculate the critical speed of instability.

Blenk, H. and Liebers, F. Gekoppelte Biegung-Torsions-und Querruderschwingungen von freitragenden und halbfreitragenden Flügeln. L.F.F., v. 4, no. 3, July 10, 1929. p. 69-93. (figures, tables, equations, references) Also D.V.L. Jahrbuch 1929, Rep. No. 129, p. 257-281.

Investigation of the forced elastic oscillations of wings. Principal extension of previous work consists in taking into account the mass of the wings. Various conditions considered. Air forces and moments and their partial differential coefficients with respect to incidence determined by experiment and calculations. Differential equations of oscillations formed and solved for small oscillations in the usual way, and conditions for stability obtained by Routh's method.

Burgess, C. P. The Torsional Strength of Wings. N.A.C.A., Tech. Rep. No. 329, 1929. 14 p. (figures, tables)

Describes a simple method for calculating the position of the elastic axis of a wing structure having any number of spars. An analytical procedure for finding the contribution of the drag bracing to the torsional strength and stiffness is described. The torsional strength of a wing largely determines the distribution of air forces upon it and the tendency of the wing to flutter. A coefficient for comparing the torsional rigidity of different wings is derived in this report.

Delanghe, G. Les Vibrations de Flexion et de Torsion d'une Aile en Porte à Faux. Technique Aeronautique, v. 20, no. 95, Sept. 15, 1929. p. 173-185; no. 96, Oct. 15. p. 187-193. (figures, equations)

The usual theory of small vibrations is developed. The elastic axis is defined, etc. The linear differential with constant coefficients and the resulting criteria for stability are given.

Duncan, W. J. and Frazer, R. A. Wing Flutter as Influenced by the Mobility of the Fuselage. British A.R.C., R. & M. No. 1207, Sept. 1929. 33 p. (appendices, figures, tables, references)

The critical speed at which instability develops in flight will be influenced by the mobility of the fuselage since the fuselage and wing form a single dynamical system, all parts of which participate in vibration. The importance of this effect is found. The theory is restricted to the case of a monoplane in rectilinear flight at small angles of incidence; biplanes briefly considered. Approximate theories of longitudinal-symmetrical and lateral-symmetrical flutter worked out. Some experimental confirmation of the theories has been obtained.

Duncan, W. J. The Wing Flutter of Biplanes. British A.R.C., R. & M. No. 1227, Sept. 1929. 60 p. (appendices, figures, tables, references)

Theoretical treatment of wing flutter of biplanes based upon and an extension of R. & M. No. 1155. Conclusions regarding biplanes with equal and unequal overhangs. List of 20 design recommendations for the prevention of wing flutter. Complete justification for all the measures is not presented. Part II deals with wind tunnel experiments upon wing flutter of biplanes on models at the National Physical Laboratory.

Essers, I. geb. Kober Untersuchung von Flügelschwingungen im Windkanal. L.F.F., v. 4, no. 4, July 17, 1929. p. 107-132. (figures, tables, equations, references)
Also Zeit. Tech. Phys., v. 10, no. 9, Sept. 1929. p. 353-361.
D.V.L. Jahrbuch 1929, Rep. No. 137. p. 345-370.

Vibrations generated by air currents. Tests in the wind tunnel. Fatigue vibrations or small resonance vibrations of some constructional parts with the cause of fatigue of material. Comparison of results and values calculated according to Blenk and Lieber's method are given. Communications of the German Testing Laboratory of Aviation.

Frazer, R. A. Aeroplane Wing Flutter. Aircraft Engineering, v. 1, no. 3, May 1929. p. 94-97; no. 4, June. p. 138-145. (figures, tables, references)
Also Roy. Aero. Soc.-Jl., v. 33, no. 222, June 1929. p. 407-454.

Detailed discussion of measures for the avoidance of oscillation of aeroplane wings. Paper contains a statement of recommendations made in R. & M. No. 1155, and the non-mathematical explanations of their meaning.
Part I - Principles of flutter prevention.
Part II- Results of experimental tests of the theory.
Part III- Actual design recommendations.

Glauert, H. The Force and Moment on an Oscillating Aerofoil. British A.R.C., R. & M. No. 1242, March 1929. 17 p. (figures, tables)

General equations for the force and moment on a body with varying circulation have been developed and applied to the problem of a straight line aerofoil performing a steady angular oscillation. Conclusions and recommendations for further developments.

Küssner, H. G. Schwingungen von Flugzeugflügeln. L.F.F., v. 4, no. 2, June 10, 1929. p. 41-62. (figures, tables, equations, references)
Also D.V.L. Jahrbuch 1929, Rep. No. 134. p. 313-334.

An indefinite wing, with or without ailerons, is dipped into a fluid which has a given speed V. Then an oscillating motion around a determined axis is given to the wing. Determination of the various speeds of the wing (with or without ailerons) and of the moment of resultant air forces. Determination of the damping force that the moment of resultant air forces has on the oscillations. For a determined speed, the oscillations are not completely eliminated but tend to maintain a definite value. This is what is called critical or stalling speed.

Küssner, H. G. Angefachte Flügelschwingungen. Zeit. Tech. Phys., v. 10, no. 9, Sept. 1929. p. 345-353. (figures, equations, references)

Vibrations explained. Vibrating of the wing in smooth air current. Origin of vibrations resulting from air currents and mathematical analysis and application of same on airplane wings. Communication of the German Testing Laboratory for Aviation.

Küssner, H. G. Flügelschwingungen an Flugzeugen. Z.A.M.M., v. 9, no. 6, Dec. 1929. p. 492-493. (references)

Author discusses the real cause of vibration and the lack of resistance of wings and other parts of the airplane to flutter. Experimental investigation based on the work of Birnbaum.

Leduc, R. Contribution à l'Etude des Poutres Prismatiques. Service Technique de l'Aeronautique, Bul. No. 60, June 1929. p. 1-47. (equations)

Determination of the torsional axis of a girder of open section with large length to cross-sectional ratio, which makes possible the calculation with precision of the resistance to deflection of transverse secondary elements connecting longerons. Formula evolved to cover the buckling of such girders in torsion, and also for the resistance to torsion of similar girders of closed section. Results applied to the case of the critical speed at which the wing of an aeroplane becomes unstable in torsion.

Maher, J. Über die kritische Länge von Flugzeugflügeln. Z.F.M., v. 20, no. 6, March 28, 1929. p. 143-145. (figures, equations)

Applying the usual methods of analysis for forced vibrations, the author finds that there is a critical length at which vibration sets in, which is related to the loading, the bending stiffness, the distance between spars, and the torsion, in a definite manner. Some of these relations given graphically.

Nagel, F. Flügelschwingungen in stationaren Luftstrom. L.F.F., v. 3, no. 5, May 5, 1929. p. 111-136. (figures)

Investigation of vibration of wings and rudders and resistance of materials. Tabular data and charts are given by which the process of mathematical analysis and experimental tests are described.

Ower, E. Recent Progress in Aerodynamics. Discovery, v. 10, no. 114, June 1929. p. 183-187. (figures)

Results of recent aerodynamic research. Included is a discussion of wing flutter.

Rauscher, M. Über die Schwingungen freitragender Flügel. L.F.F., v. 4, no. 3, July 10, 1929. p. 94-106. (figures, equations)

Discussion of oscillations in which the fact is considered that the elastic axis of the system has a deformation due to static load which is independent of the oscillations. The static and dynamic forces acting on a generic element of the elastic axis is studied. D'Alembert equations are written and the equations of the elastic axis are found. Diagram of torsions.

Relf, E. F. Research Progress - 1928. Aircraft Engineering, v. 1, no. 1, March 1929. p. 7-8.

Review of research progress of the year dealing with those investigations which seem to be of the greatest importance. One of these has been the study of wing flutter. Review of theories on wing flutter. These theories apply only to an unbraced monoplane wing and experiments are now in progress to determine how far they may be applied to the short overhangs of a biplane structure.

Scheubel, F. N. Fluttering of the Tail Surfaces of an Airplane and the Means for Its Prevention. N.A.C.A., Tech. Mem. No. 498, Jan. 1929. 16 p. (figures, discussion) Translated from Wissenschaftlichen Gesellschaft fur Luftfahrt Jahrbuch, No. 14, Dec. 1926. p. 103-107.

This article is a continuation of the work of Baumhauer and Konig and is restricted to fluttering of tail surfaces and especially to oscillations of the horizontal empennage. It illustrates characteristics of all other phenomena of fluttering. Gives qualitative explanation of negative damping. Theoretical examples given and also results of calculation in an attempt to aid the constructor who is interested in the location of flutter and dependence of critical speed.

Spencer, K. T. and Seed, D. Comparison of Calculated and Measured Elasticity of the Wings of an Aircraft in Connection with the Investigation of Wing Flutter. British A.R.C., R. & M. No. 1257, April 1929. 9 p. (appendix, figures, tables)

Comparison is made between stiffness of an aircraft wing as calculated from drawings, and as measured from mechanical test. Appendix gives an account of the mechanical test. In general, there is good agreement between the calculated and measured values of the deflections.

Stieger, H. J. Cantilever Wings for Modern Aircraft. Aircraft Engineering, v. 1, no. 6, Aug. 1929. p. 187-190. (figures)

Some aspects of cantilever wing construction with special reference to weight and torsional stiffness. Paragraph dealing with distortion and flutter. Several failures have occurred as a result of making the wing structure too flexible. In R. & M. No. 1177, the exact nature of the phenomenon of wing flutter has been well defined. Providing that certain fundamental rules are observed, there should be no difficulty in constructing a cantilever wing in which the likelihood of flutter is very remote.

Victor, M. The Danger of Wing Vibrations. Les Ailes, no. 375, 1929. (In French)
Also Rivista Aeronautica, v. 5, no. 8, Aug. 1929. p. 359-361.

Complete critical study on flying accidents due to wing flutter. To avoid such danger, it is necessary, first, to reduce the load of the aileron and its moment of inertia, then to increase the stiffness of the aileron control in order to eliminate the disturbing moment. The problem of vibration is not solved completely, but the necessity for such a solution is pointed out.

Winters, S. R. Taking Out the "Shimmies". Popular Aviation, v. 4, no. 3, March 1929. p. 30-31. (figures)

Government investigation prompted by defects in structural vibration of certain aircraft. Description and explanation of tests made in a wind tunnel with model MO-1 plane. Special emphasis is given to the tail unit. Experiments had for their objective the exposure of causes and suggestion of remedies whereby the plane designer could eliminate undue wing vibrations.

Alippi, C. Una Verifica Grafica della Stabilita alle Oscillazioni Torsionali di un Ala Monoplana a Longherone. L'Aerotecnica, v. 10, no. 11-12, Nov.-Dec. 1930. p. 821-830. (figures, equations, references)

Résumé of the studies of Blasius and Reissner on the problem of torsional oscillations of a single spar monoplane wing. The author extends application of their concepts by eliminating only those restrictive of the constant chord and stiffness. The method consists in determining, through two successive attempts of graphical integration and for any assumed velocity, the elastic torsional deformations in the various spar sections. The method is applied to the case of constant stiffness and constant wing chord, and comparison shows good agreement with the formula applicable in this case.

Bouchenot, M. R. Vibration of Cantilever Wings. Soc. Générale de l'Aeronautique, Rev., Oct. 1930. p. 16-20. (In French)

Gives elementary theory of vibration of wings and concludes that torsional rigidity is the most important factor in determining the lowest critical speed. A photograph of monoplane cantilever construction with internal bracing mounted for determination of torsional rigidity, and the critical speed is shown graphically as a function of the torsional rigidity.

Carpenter, S. R. The Calculation of the Natural Frequency of a Cantilever Monoplane Wing. A.C.I.C., v. 7, no. 649, March 1, 1930. 13 p. Air Corps Tech. Rep. No. 3173. (appendix, figures)

Presents practical application of the calculation of the natural frequency of a stressed skin monoplane wing, in bending and in torsion. The calculations are applied to the Fokker C-2A monoplane wing and compared with experimental results of A.C.I.C. No. 645.

Duncan, W. J. and Collar, A. R. Tail Flutter of a Particular Aeroplane. British A.R.C., R. & M. No. 1247, May 1930. 24 p. (figures, tables)

Investigation of an accident to a particular aeroplane, which occurred during a test flight, due to tail flutter of the rudder-fuselage type (based upon theory of tail flutter developed in R. & M. No. 1237). To calculate the critical flutter speed, two groups of coefficients are needed: (1) appropriate inertial and stiffness constants of actual machine. This was determined at the Royal Aircraft Establishment by direct experiments and calculations from drawings; (2) dynamical coefficients for rudder-fuselage motion deduced from experiments at the National Physical Laboratory in the wind tunnel with 1/8 scale model. General conclusions regarding the accident.

Fradiss, J. and Thieblot, A. Construction of Airfoil Sections and Wing Generation. Aviation, v. 28, no. 2, Jan. 11, 1930. p. 61-64.

The first of two articles on a systematic method of designing airfoils. The first is a simplified and condensed outline of the method of construction of theoretical airfoils and wings without any mathematical development or detail. The second is a practical method of graphical construction of theoretical airfoils and wings. Includes discussion of flutter. Wing flutter is not solely dependent upon statical strength of the wing. It cannot always be eliminated by an increase of strength. The danger of wing flutter increases with: (1) the center of pressure travel; (2) the fact that the cruising angle of attack is near to the angle of zero lift; (3) the lack of torsional rigidity. Recommendations given in designing a wing to avoid these conditions.

Frazer, R. A. and Duncan, W. J. The Flutter of Aeroplane Tails. British A.R.C., R. & M. No. 1237, Jan. 1930. 27 p. (appendices, figures, tables, references)

Part I - Survey of the dynamical theory of tail flutter and divergence. The motions discussed involve twist of the fuselage, flapping of the elevators and rudder, and distortion of tailplane and fin. Criteria for stability examined. Simple sufficient conditions for the avoidance of flutter deduced.

Part II- Account of wind tunnel experiments, the results of which are in accord with the theoretical conclusions. Suggestions regarding design.

Greene, C. F. and Younger, J. E. Study of Wing Flutter. Part II - Continuation of Tests on Revised Apparatus at Wright Field Wind Tunnel. A.C.I.C., v. 7, no. 653, Aug. 30, 1930. 21 p. Air Corps Tech. Rep. No. 3237. (appendices, figures)

General non-mathematical survey of the phenomena of forced vibrations in wings. The influence of natural periods, camber and dimensions expressed in empirical formulae. Relations between frequency of vibration and air speed given graphically for different incidences, positions of the elastic axis, mass distribution and dimensions. Abstract of recommendations of Frazer and Duncan.

Howard, B. O. Howard Racing Plane. Aero Digest, v. 17, no. 5, Nov. 1930. p. 62.

Construction of plane described. Special attention was given to the wing tips to reduce the end losses, assure efficiency, and eliminate any possible chance of flutter.

Relf, E. F. Progress of Aerodynamic Research in 1929. Aircraft Engineering, v. 2, no. 11, Jan. 1930. p. 5-6.

A brief review of the work done at the National Physical Laboratory during the year on certain fundamental aerodynamical problems, among them being problems of flutter. Wing flutter has been analyzed throughout the year. The question of tail flutter worked on, the theory worked out, followed by tests on specially flexible models in the wind tunnel. Differences between flutters associated with the tailplane and those of the wing. Measures beneficial in the case of eliminating tail flutter. Another important flutter problem dealt with is that of airscrew flutter and the difficulties involved. Complex analysis which does not appear to lead to such simple and easily applied remedies. Means are being sought to check the theoretical conclusions by means of models.

Soulages, E. La Cause Principales de la Rupture en Plein Vol. Premier Congrès International de la Sécurité Aérienne, Paris, v. 1, part 3, 1930. p. 61-65. (equations)

The author believes that too much attention is given to the vibrations in wings as the cause of rupture.

Spere, C. J. Determination of the Elastic Axis and Natural Periods of Vibration of the Atlantic C-2A Monoplane Wing. A.C.I.C., v. 7, no. 645, March 1, 1930. 10 p. Air Corps Tech. Rep. No. 3097. (figures)

This test is the first of a group of tests to determine the elastic characteristics of a series of internally braced monoplane wings, which have shown no dangerous wing-flutter characteristics and have been proven satisfactory in service, in an effort to establish certain criteria for judging the merit of future designs with respect to the elastic characteristics of internally braced monoplane wings. Tests aim to determine, among other things, the natural frequency of vibration of wing in bending and in torsion. The procedure and results of tests are given.

______________ Accident to the Aeroplane G-AAZK at Meopham, Kent, on July 21, 1930. British A.R.C., R. & M. No. 1360, Jan. 1931. 92 p. (appendices, figures, tables)
Also Aviation Engineering, v. 4, no. 3, March 1931. p. 24-25.

Investigations involving the accident to the aeroplane G-AAZK, a low-wing monoplane. Various theories as to the cause of the accident are considered. Experiments with a model of the plane were carried on at the National Physical Laboratory on tail flutter, buffeting, and vibration. Conclusion - buffeting caused the accident.

______________ A Fresh Phenomenon. Aircraft Engineering, v. 3, no. 24, Feb. 1931. p. 25-26.

Discusses the importance to be attached to buffeting. Report of the accident to the Junkers monoplane in Kent attracts attention to the phenomenon of buffeting.

______________ The Phenomenon of "Buffeting". Aircraft Engineering, v. 3, no. 24, Feb. 1931. p. 31-34. (references)

A new aeronautical term is introduced by the Accidents Investigation Sub-Committee in their report on the accident to the Junkers F.13 type aeroplane at Meopham, Kent. "Buffeting" is attributed to eddies given off by the wings at large angles of incidence and acting periodically on the tail.

______________ The Amiot 140 M Military Airplane (French). N.A.C.A., Aircraft Circular No. 134, Feb. 1931. 7 p. (figures)
Translated from L'Aeronautique, v. 12, no. 139, Dec. 1930. p. 480-484.

Description of features of the Amiot M military airplane, an all-metal multiplace high-wing monoplane. Included is a description of the three-spar wing system, which has been found advantageous for withstanding torsional stresses and preventing vibration by giving the wing good torsional rigidity.

______________ Puss Moth Aircraft: Navigation Tail Lamps. No. 49, 1931, D.H. 8CA. Flight, v. 23, no. 37, Sept. 11, 1931. p. 929.

There appears to be a possibility of rudder flutter on aircraft of the above type when a heavy tail lamp is attached to the trailing edge of the rudder. Modification incorporating a very light tail lamp in low position on the rudder has been introduced.

______________ The Supermarine S-6-B Racing Seaplane (British). Aircraft Engineering, v. 3, no. 32, Oct. 1931. p. 247-248. (figures)
Also N.A.C.A., Aircraft Circular No. 154, Dec. 1931. 6 p.

Description of the S-6-B racing seaplane, a low-wing, twin-float monoplane with cantilever wing unit. Mass balances were fitted to the ailerons and rudder with a view to obviating any possibility of flutter.

______________ Relazione Finale della Commissione d'Inchiesta sull'Incidente dell'Apparecchio S-64. L'Aerotecnica, v. 11, no. 12, Dec. 1931. p. 1612-1626. (figures)

Summary of investigation of the S64 accident as reported by the investigations committee. The accident was due to breakage of the wing. The article refers to the G-AAZK Junkers monoplane accident in comparison to the S64 accident.

Bouchenot, M. R. Contribution à l'Etude des Vibrations des Surfaces Portantes. Soc. Générale de l'Aeronautique, Rev., July 1931. p. 38-41.

A brief mathematical account of the method of calculating the natural period of wing structure. Experimental methods of determining natural period described and illustrated by diagrams. Calculated and experimental results are compared in tables and agree roughly.

Brown, C. G. Torsional Rigidity in Cantilever Wings. Aviation Engineering, v. 5, no. 5, Dec. 1931. p. 11-14. (figures)

Definitions and formulae for flutter. Determination of the coefficient of torsional rigidity. Rigidity characteristics of wings of different construction.

Cox, H. R. Cases of Purely Torsional Loading on Stripped Aeroplane Wings. British A. R.C., R. & M. No. 1436, Aug. 10, 1931. 12 p. (figures, tables)

It is important to calculate the torsional stiffnesses of wings in the course of investigations of wing flutter. Report gives equations developed for distortion under different forms of applied torque of a wing with two spars of constant section connected by stiff ribs. Approximate formulac are given for calculation of the torsional stiffness of an actual wing.

Duncan, W. J. The Use of Models for the Determination of Critical Flutter Speeds. British A.R.C., R. & M. No. 1425, July 1931. 5 p.

Discusses the technique of model tests in the prediction of full-scale critical flutter speeds. In order to obtain critical speeds for model, within the speed range of ordinary wind tunnels, the model should differ from the mere small-scale replica of full-scale aeroplane. Report considers the relation of model and full-scale stresses at the critical flutter speeds. Also considers the influence of gravity on flutter.

Frazer, R. A. and Duncan, W. J. The Flutter of Monoplanes, Biplanes and Tail Units. British A.R.C., R. & M. No. 1255, Jan. 1931. 179 p. (appendices, figures, tables, references)

Elementary review of the principles of flutter of aeroplane wings, with a description of simple experiments on models. Chap.I - Theoretical analysis of various types of oscillations. (Issued as R. & M. No. 1207) Chap. II - Theoretical analysis of the conditions for the prevention of flexural torsional flutter of an elastic wing. (Issued as R. & M. No. 1217) Chap. III - Theoretical treatment of wing flutter of biplanes based on the theory developed in R. & M. No. 1155. List of design recommendations. Also wind tunnel experiments on wing flutter of biplanes. Chap. IV - Theoretical investigation of flutter of aeroplane tails. (Issued as R. & M. No. 1237) Also experimental investigation. Chap. V - Tail flutter of a particular plane. (Issued as R. & M. No. 1247) Investigation of an accident during a test flight. Accident due to tail flutter of the rudder-fuselage type.

Glazebrook, R. Aeronautical Research in England. Aircraft Engineering, v. 3, no. 25, March 1931. p. 63-66. (tables, references)

Reviews the work of the organization of the British Aeronautical Research Committee. Includes a brief discussion of the research on flutter which lead to the creation of a special Flutter Sub-Committee to deal with the subject. R. & M. No. 1155 monograph published as a result of this research.

Hartshorn, A. S. and Douglas, G. P. Wind Tunnel Experiments on High Tip Speed Airscrews. British A.R.C., R. & M. No. 1438, July 1, 1931. 12 p. (figures, tables, references)

During a course of tests for lift and drag coefficients, the phenomenon of flutter was also observed. No appreciable flutter was observed with blades 0.10c thick or thicker. During tests of the 0.082c airscrews, flutter could be obtained at certain critical speeds, but in the case of the 0.06c airscrew, there was a fairly well defined region in which running was impossible due to blade flutter.

Higuchi, S. On the Forced Vibration of an Elastic Rod. Tohoku Imp. Univ., Sci. Rep., v. 20, no. 3, 1931. p. 399-432. (figures, tables, equations, references) (In English)

Study of the stability of tall and thin constructions (smoke stacks, light houses, etc.) and their reaction to earthquakes. This study has some aeronautical interest because of its similarity to the problem of the flexural vibrations of cantilever wings. Experiment is performed on a body fixed at one end and forced to a uniform motion. Stiffness and mass of body are supposed to be uniform, too. Considers only the elastic damping and not the aerodynamic one, which in this case, has no influence. Gives some theoretical diagrams of the vibrations for some specific cases.

Léglise, P. The Dewoitine D-33 Commercial Airplane (French) N.A.C.A., Aircraft Circular No. 146, June 1931. 9 p. (figures)
Translated from L'Aeronautique, v. 13, no. 144, May 1931. p. 155-163.

Airplane of great fineness was built by developing a cantilever wing with the greatest aspect ratio ($\lambda = 10$) compatible with structural weight of 2.05 lb. per sq. ft. Description of wing. Usual difficulties in eliminating vibration in wings of aspect ratio of 10 overcome in D-33.

Le Page, W. L. Design Problems of the Autogiro. S.A.E.-Jl., v. 29, no. 5, Nov. 1931. p. 372-378. (figures, discussion)

Statics of dynamic balance, control of machine in flight and descent, control of rotor speed and of oscillation of rotor blades, design of suitable landing gear, etc.

Parker, A. E. Wing Oscillation. Flight, v. 23, no. 48, Nov. 27, 1931. p. 1174a-1174c. (figures)

Two cases of wing vibration are worked out mathematically. In the first case, the effect of bracing is entirely omitted except in regard to the weight of the wing, and only the spars are considered. In the second case, the loading on the wing is not calculated as constant along the span, but the wing is considered as without lift at the center section immediately above the cabin. Tapered wings are used and an elliptic distribution of pressure over the span, modified for the tapering of wings, is assumed.

Poggi, L. Azioni Aerodinamiche Parallele al Movimento su di un'Ala Piana Animata da Moto Traslatorio Uniforme e da Moto Oscillatorio. L'Aerotecnica, v. 11, no. 6-7, June-July, 1931. p. 767-779. (figures, tables, equations)

Calculation of the average value of component along directions of motion of aerodynamical actions acting on an indefinite plain wing endowed with a uniform translatory motion and with a waving motion around a point of the chord of its prolongation. Based on formulae by Glauert. The average value of such component given in a form referring to the wing length. Result - that some propulsive forces of the order of magnitude of drag of wing are obtainable in practice at the expense of power necessary to oscillate the wing. Comparison of power (calculated according to Glauert) and propulsion; efficiency obtained with satisfactory results.

Tyler, E. Vortex Formation Behind Obstacles of Various Sections. Phil. Mag., S. 7, v. 11, no. 72, April 1931. p. 849-890. (figures, tables, equations, references)

Determination of the frequency of formation of vortices behind inclined airfoils and plates over wider range of inclination than in previous paper, by different methods and also for cylinders at low values of Reynolds number. Hot wire methods for determining longitudinal and lateral spacings of vortices behind obstacles, with their application to cylinders, airfoils and plates.

Verdurand, A. Les Tendances Actuelles de la Technique Aeronautique. Technique Moderne, v.23, no. 5, March 1931. p. 151-159. (figures)

Included is a section on the dangers of wing tip vibration. Explanation of the causes of these vibrations (among them the displacement of the point of application of the resultant forces with the change of incidence) as well as the solution adopted in the construction of wing frames.

Walker, C. C. Strength of the Puss Moth. Flight, v. 23, no. 28, July 10, 1931. p. 660.

Discussion of the accident to the Puss Moth in October 1930, which resulted in modifications to the wings and ailerons in order to eliminate the possibility of flutter. A second accident took place in South Africa. Although the machine had not been modified, the accident was not due to wing flutter. The plane was flying overloaded and in exceptionally violent weather.

______________ I Lavori e i Risultati della Commissione d'Inchiesta sugli Incidenti di Breda 33. L'Aerotecnica, v. 12, no. 10, Oct. 1932. p. 1423-1425.

Report of investigations into two accidents to the Breda 33 in August 1932. Accidents were caused by violent fluttering of the wings.

______________ The Messerschmidt M 29 Touring Airplane (German). N.A.C.A., Aircraft Circular No. 172, Nov. 1932. 8 p. (figures) From information furnished by the manufacturers, the Messerschmidt Aeroplane Mfg. Co., G.m.b.H., Augsburg, Germany, and the Z.F.M., October 14, 1932.

Description of the M 29, a two-seat cantilever monoplane. Constructional details of the wing structure include drawn-in-flap; therefore at high speed, the wing profile is equivalent to a profile with a fixed center of pressure, so that the torsional stresses of the wing are small. The wing structure consists of a torsionally rigid leading-edge formed by the single spar and the leading-edge planking. This has the advantage of an especially high critical speed as regards vibrations.

Blenk, H., Hertel, H. and Thalau, K. The German Investigation of the Accident at Meopham, (England). N.A.C.A., Tech. Mem. No. 669, April 1932. 29 p. (figures, references)

Translated from Z.F.M., v. 23, no. 3, Feb. 15, 1932. p. 73-86.
Also D.V.L. Jahrbuch 1932, Rep. No. 267, part III, p. 1-14, 36.

Exhaustive study of this accident comprising static and dynamic strength tests, flight tests and wind-tunnel experiments by the D.V.L. Brief review of the English investigation and its findings. Because of these findings, the Germans instituted experiments on tail buffeting - its cause, intensity, and gravity. The program included experimental flights, model tests and tensile strength tests. Recapitulation of the German test data. Conclusions. As a result of the German investigation, it is believed that primary failure occurred in the wings as the result of a too rapid pull-out from a dive and not from buffeting.

Cox, H. R. A Statistical Method of Investigating the Relations Between the Elastic Stiffnesses of Aeroplane Wings and Wing-Aileron Flutter. British A.R.C., R. & M. No. 1505, Oct. 17, 1932. 30 p. (appendices, figures, tables, references)

Report describes and illustrates a statistical method for obtaining minimum stiffnesses which wings of a particular aircraft should have to preclude flutter at all speeds of which it is capable. This information can be used to deduce the minimum safe stiffnesses for aircraft with no specific anti-flutter design features and for aircraft embodying such features.

Duncan, W. J. and Collar, A. R. Calculation of the Resistance Derivatives of Flutter Theory. Part I - British A.R.C., R. & M. No. 1500, Oct. 8, 1932. 14 p. (figures)

Mathematical analysis extended beyond that done by Glauert in R. & M. No. 1242. Discussion of the effect of frequency of oscillation on aerodynamical derivatives based on Wagner's theory. Complete set of derivatives obtained which are the two-dimensional analogues of the flexural-torsional derivatives of the theory of wing flutter which are applicable for steady sinusoidal oscillations which have persisted for infinite time. Formulae for the reactions on a rectilinear aerofoil in two-dimensional motion.

Duncan, W. J., Ellis, D. L. and Scruton, C. First Report on General Investigation of Tail Buffeting. British A.R.C., R. & M. No. 1457, Feb. 1932. p. 1-18. (appendices, figures, tables, references)

Experiments on tail buffeting conducted by the National Physical Laboratory. Investigation begins with the case where the aerofoil (R.A.F. 31) creating the disturbance is of infinite ratio. Arrangement used ensures that the detector (playing the part of the buffeted tailplane) has only a single natural frequency of oscillation. Results of the experiments summarized. Description of the apparatus. Suggestions for future work.

Duncan, W. J., Frazer, R. A. and Falkner, V. M. Experiments on the Buffeting of the Tail of a Model of a Low-Wing Monoplane. British A.R.C., R. & M. No. 1457, Feb. 1932. p. 19-36. (figures, tables) Second Report.

Experiments to investigate the influence of wing section, airscrew slipstream, tailplane stiffness, and other factors on tail buffeting of a model of a low-wing monoplane. Three sets of rigid wings used. Results briefly summarized, not analyzed. Measurements of deflections in buffeting summarized in Tables 1-7, and plotted. Experimental and mathematical tabulation of results.

Lockspeiser, B. and Callen, C. Wind Tunnel Tests of Recommendations for Prevention of Wing Flutter. British A.R.C., R. & M. No. 1464, Feb. 11, 1932. 32 p. (appendix, figures, tables, references)

Wind tunnel tests carried out, on a model of an actual wing structure, of the recommendations relative to ailerons put forward in R. & M. No. 1155, which is theoretical, for the prevention of wing flutter. Conclusions regarding each recommendation.

Pugsley, A. G. The Influence of Wing Density upon Wing Flutter. British A.R.C., R. & M. No. 1497, June 21, 1932. 16 p. (figures, tables, references)

Theoretical determination of the general nature of the influence of wing density on wing flutter. The effects upon binary and ternary flutter are treated analytically and then illustrated by a numerical application of the theory to a particular example. Some general information on its effects upon critical speed and frequency.

Smirnoff, V. and Soboleff, S. Sur le Problème des Vibrations Élastiques. Inst. de France, Acad. des Sciences, Comptes Rendus, v. 194, no. 17, April 25, 1932. p. 1437-1439.

The object of this paper is to develop a new method for the solution of elastic vibrations in the case of a half-wing or its sections. This method is also valuable for three-dimensional problems or in place of axial symmetry. It is a mathematical discussion with applications to the case of the longitudinal vibrations of the half-wing.

Smirnoff, V. and Soboleff, S. Sur Quelques Problèmes de Vibrations Élastiques. Inst. de France, Acad. des Sciences, Comptes Rendus, v. 194, no. 20, May 17, 1932. p. 1797-1799.

Mathematical discussion of the source of transverse vibrations of a half-wing or its sections.

Stieger, H. J. Wing Construction. Roy. Aero. Soc.-Jl., v. 36, no. 262, Oct. 1932. p. 789-827. (figures, discussion)

Lengthy discussion on wing structure. The author introduces the controversial subject of the single versus the two or multi-spar system of construction. With regard to flutter, the author states that a single spar at about .28-.30 of the chord, a correspondingly low moment of inertia for the wing, and a principal inertia axis approximately coinciding with the flexural axis, is as near the ideal as possible; full scale tests confirmed this. The problem of wing root interference is discussed, especially in low-wing monoplanes, in its reference to tail buffeting.

Williams, D. Distortions of Stripped Aeroplane Wings Under Torsional Loading. British A.R.C., R. & M. No. 1507, Aug. 11, 1932. 23 p. (appendices, figures, tables, references)

A knowledge of torsional stiffness of wings is necessary to a study of the characteristics of aeroplane flutter. The problem treated in this report is that of finding the torsional stiffness of an aeroplane wing that consists of two spars connected together by stiff ribs at frequent intervals along the span. Method used is one graphical successive approximations. Example worked out in detail to illustrate the procedure adopted.

_______________ The Comper "Mouse". Aeroplane, v. 45, no. 13, Sept. 27, 1933. p. 569-573. (figures)
Also N.A.C.A., Aircraft Circular No. 184, Oct. 1933. 5 p.
Flight, v. 25, no. 39, Sept. 28, 1933. p. 973-978.

Description of the Comper "Mouse" commercial airplane, a 3-seat cabin low-wing monoplane. Innovation in the method of folding the wings. By this ingenious system, the main spar fittings are protected against the development of shape which might lead to wing flutter.

_______________ Damping Elevator Vibration. Aviation, v. 32, no. 11, Nov. 1933. p. 348.

High speeds introduce many problems, one of which is the elimination of elevator flutter, which is apt to occur at speeds in excess of 200 m.p.h. The heavier the elevator, the more tendency to flutter; thus metal surfaces should be used sparingly. An effective means of dampening out possible vibrations of wood elevators developed by Lockheed Aircraft Corp. for the new Orion low-wing monoplane (226 m.p.h. top speed). Description of vibration dampener or counter-balance which gives a 70% static balance around the elevator hinge, reducing the moment of the elevator to 30%. No attempt to achieve dynamic balance.

Biecheteler, C. Tests for the Elimination of Tail Flutter. N.A.C.A., Tech. Mem. No. 710, June 1933. 14 p. (figures, references)
Translated from Z.F.M., v. 24, no. 1, Jan. 14, 1933. p. 15-21.
Also D.V.L. Jahrbuch 1933, Rep. No. 309, part IV, p. 11-17.

Causes of tail flutter on a low-wing monoplane and the means of preventing it. A BFW-M23b airplane was used for the investigation. Possibilities of eliminating tail buffeting. Various methods of preventing premature separation of the wing flow are outlined. Tests for the elimination of tail flutter. Comparison of the performance of the experimental airplane, with and without fairing.

Blenk, H. Über neuere Englische Arbeiten zur Frage des Leitwerkschüttelns. Z.F.M., v. 24, no. 1, Jan. 14, 1933. p. 21-24. (figures, references)
Also D.V.L. Jahrbuch 1933. (appendix to) Rep. No. 267, part IV, p. 7-10.

By reason of the almost simultaneous appearance of the English and German reports on the Meopham accident (D.V.L. Rep. No. 267 and R. & M. No. 1360), no comparison of test results was made in either report. This summary is therefore given for the information of German readers of the more recent R. & M. No. 1457.

Blenk, H. A German View of Buffeting. Aircraft Engineering, v. 5, no. 51, May 1933. p. 113-115. (figures, references)

A comparison between the British and German investigations into the Meopham accident. Technical opinion in Germany does not agree with the British verdict that the accident to the Junkers was due to buffeting. In this article a member of the D.V.L. staff examines the latest National Physical Laboratory investigations of the subject and gives his reason for casting doubt on the British view.

Duncan, W. J. and Collar, A. R. A Theory of Binary Servo-Rudder Flutter, with Applications to a Particular Aircraft. British A.R.C., R. & M. No. 1527, Feb. 13, 1933. 23 p. (figures, tables, references)

A theory of servo-rudder flutter with a detailed application to the rudders of a certain aeroplane. Rudder flutter may be avoided by methods quite similar to those already devised for the prevention of torsional-aileron flutter. The results of the theoretical enquiry into the flutter characteristics of the rudder of a particular aircraft are presented. Data for the calculation of critical flutter speeds.

Duncan, W. J., Ellis, D. L. and Smyth, E. Second Report on the General Investigation of Tail Buffeting. British A.R.C., R. & M. No. 1541, May 30, 1933. 16 p. (figures, references)

The investigation covers tests of two aerofoils of infinite aspect ratio, an aerofoil of finite aspect ratio, and several wing-body combinations with and without special devices for the prevention of tail buffeting. Experiments were carried out to find out whether a sudden increase of wing incidence can produce buffeting more severe than corresponded to the final incidence under steady conditions. Devices and design recommendations for the prevention of tail buffeting.

Ellis, D. L. An Irreversible Control Gear. Aircraft Engineering, v. 5, no. 55, Sept. 1933. p. 207-208. (figures)

A recently patented hydraulic motor car steering damper appears to have a possible application as an irreversible control for the prevention of aileron flutter, and a suggested method of applying the device to a control system is described. Diagrams show application of damper for aeroplane use.

Gazley, R. C. How Accidents Affect Design. Part II - Wing and Control. Western Flying, v. 13, no. 8, Aug. 1933. p. 12-13. (figures)

Includes discussion of deflection and flutter. Tendency for wing to flutter is always present in a dive because the wing is operating at an angle of attack such that any small change in that angle will cause reversal of load on the forward part of the wing. Investigation of the accidents due to wing structure failures, which were caused primarily by fitting failures, has shown that there exist a few fundamental principles which need to be more fully recognized and taken into account.

Guglielmetti, A. Oscillazioni di Torsione delle Ali a Sbalzo. Rivista Aeronautica, v. 9, no. 3, March 1933. p. 423-432. (figures)

A critical study of a report by A. Raab, Z.F.M., v. 17, no. 7, April 14, 1926, p. 146-147. The author extends his study on torsional oscillation of cantilever and semi-cantilever wings, alternating stresses, elastic torsion, stiffness of the wing, position of the elastic axis, value of the twisting moment, etc., and gives to aeronautical engineers some suggestions on the behavior of the curve Cm.

Hood, M. J. and White, J. A. Full-Scale Wind-Tunnel Research on Tail Buffeting and Wing-Fuselage Interference of a Low-Wing Monoplane. N.A.C.A., Tech. Note No. 460, May 1933. 14 p. (figures, reference, discussion)
Also American Cure for Buffeting. Aircraft Engineering, v. 5, no. 55, Sept. 1933. p. 203-206.

Preliminary results of an investigation conducted in the N.A.C.A. wind-tunnel to determine the best means of reducing the tail buffeting and wing-fuselage interference of a low-wing monoplane. Data indicating the effects of N.A.C.A. engine cowling, fillets, auxiliary airfoils of short span, reflexed trailing edge, propeller slipstream, and various combinations of these features are included. The best all-round results were obtained by use of fillets plus N.A.C.A. cowling.

Howard, C. M. Materiel Division Aeronautical Developments During 1932. Air Corps News Letter, v. 17, no. 2, Feb. 24, 1933. p. 27-32.

Brief outline of the major experimental projects and developments of the engineering section of the Materiel Divisions for the past year. Under the heading of research and experimentation, developments in metal structures necessitate certain additional specific rigidity requirements. Included are such items as tail torsion tests, wing vibration and torsion tests, tests for vibration frequency of any part of an airplane suspected of possible flutter in flight.

Lockspeiser, B. A Simple Approach to the Wing Flutter Problem. Roy. Aero. Soc.-Jl., v. 37, no. 273, Sept. 1933. p. 783-792. (figures, references)

Part I - Flutter of a Wing with Locked Aileron. Theoretical discussion of the problem. Theoretical and practical recommendations for the elimination of flutter given.

Part II- Flutter of a Wing with Unlocked Aileron. Summary of conclusions regarding aileron design for the prevention of flutter, failing irreversible control.

Minelli, C. Vibrazione Libere nei Solidi e Indifferenza dell'Equilibrio Elastico Negli Alberi e nelle Ali. L'Aerotecnica, v. 13, no. 8, Aug. 1933. p. 997-1011. (figures, equations, references)

Problems of the stability of elastic equilibrium are discussed in which the importance of external forces is a function of the deformations produced by these forces on the whole. In taking up the critical speeds of shafts and wings, the author recalls and extends the well-known analogy between the critical speeds of a shaft and the true frequencies of flexional vibrations of a beam, setting forth a new analogy between the critical speeds of a single-spar wing and the true frequencies of torsional vibrations of a solid.

Panetti, M. Nuovi Problemi sullo Studio delle Vibrazioni dei Mezzi di Trasporto. Atti della Reale Accademia delle Scienze di Torino, No. 48, 1933.

As a contribution to the study of "unexplained" vibrations, the writer takes up the concepts of "associated" vibrations well-known in physics, but hitherto hardly applied to problems of mechanics, and, by help of the theory of the double oscillator, endeavors to explain the phenomenon of self-excitation. The theory is applied to the case of the main planes and tail planes of aeroplanes. Research was conducted in conjunction with the Meopham accident particularly mentioned.

Roché, J. A. Airplane Vibrations and Flutter Controllable by Design. S.A.E.-Jl. (Trans.), v. 33, no. 3, Sept. 1933. p. 305-312. (figures, tables, equations)
Also Aviation, v. 33, no. 1, Jan. 1934. p. 21-22.
A.C.I.C., v. 7, no. 687, July 10, 1934. 7 p.
Air Corps Tech. Rep. No. 3861.

Survey of the subject of vibration and flutter and suggestions for control by design. Discussion of vibration as a factor in airplane accidents. Vibration as affected by mounting, airflow, drag. Causes of buffeting and vibration preventive factors given. Discussion of vibration testing. This data should assist designers in acquiring good judgment for avoiding flutters, and may help investigators into the mathematical theory of flutters, to evaluate some coefficients and check their formulae for critical velocity.

Serby, J. E. and Alston, R. P. Full Scale Tests on the Longitudinal Control of a Low-Wing Monoplane with Special Reference to Wing Wake. British A.R.C., R. & M. No. 1666, Nov. 9, 1933. 12 p. (appendix, figures, references)

Presents the results of extensive flight tests and wind tunnel experiments made with the intention of curing air interference phenomena encountered in a certain low-wing airplane. Work in flight was mainly confined to measurement and visual observation of these phenomena. The development of turbulence at the wing root was studied by cinema records of wool tufts, and was extended to include the spread of turbulence over the whole wing culminating in the stall. The presence of tail vibrations, its cause and remedies discussed.

Vellay, E. Les Vitesses Dangereuses pour les Ailes Sustentatrices. Assoc. Technique Maritime et Aeronautique, Bul. No. 37, 1933. p. 579-595. (discussion)

Study of critical speeds for supporting wings of fast airplanes. Critical review of the theories of Prandtl and Lanchester. Critical speeds of torsion and vibration. Conclusions.

Warner, E. P. Technical Excitement at Aircraft Sessions Equals that of Flying Field Crowds. S.A.E.-Jl. (Trans.), v. 33, no. 4, Oct. 1933. p. 30-35.

General review of the research on aircraft problems including airfoils and flutter.

Williams, D. The Flexural-Torsional Flutter Characteristics of a Simple Cantilever Wing Representative of Current Practice. British A.R.C., R. & M. No. 1596, Nov. 2, 1933. 18 p. (figures, tables, equations, references)

A cantilever wing is considered. The variation of its flutter speed consequent on the variation of certain factors between limits set by current design is investigated. Shows also how the numerical values obtained during this investigation may be used to derive a quantitative estimate of the flutter characteristics of any cantilever wing.

Wittman, C. The German Research Institute. The Development, Organization and Work of the D.V.L., Described and Illustrated. Aircraft Engineering, v. 5, no. 52, June 1933. p. 121-125, 137. (figures, references)

The statics department conducted buffeting tests for the determination of stiffness, tail buffeting being particularly explored. Description of vibration device for determining the fatigue strength of components given. Work of each department of the D.V.L. described. The engine department is concerned with vibration phenomena. The flying department made observations of tail buffeting in flight at large angles of incidence and during turns in course of flights. Recommendation for the elimination of buffeting given. The work of other departments described.

__________ Design Rules for Prevention of Flutter. Air Commerce Bul., v. 5, no. 8, Feb. 15, 1934. p. 202-203.

Draft given of the design rules which are believed to represent wise and necessary precautionary measures for the prevention of destructive flutter. These design rules are now in effect for all new aircraft having a top speed in excess of 150 miles per hour.

__________ The Comper "Streak". Flight, v. 26, no. 16, April 19, 1934. p. 377-381. (figures)
Also N.A.C.A., Aircraft Circular No. 194, July 1934. 4 p.

During the first flight of "Streak", a low-wing cantilever monoplane, the ailerons were found to be extremely sensitive, so much so, that flutter developed. The flutter occurred at high speed only, and modern theory indicates that, in nearly all cases, a tendency to flutter can be cured by mass balances. This case of flutter was eliminated by the installation of mass balances on a narrow chord aileron. (See May 3 issue of Flight)

__________ Aviation Research on Parade. Aviation, v. 33, no. 7, July 1934. p. 201-204.

Ninth Langley Field Conference of the N.A.C.A. Included is a brief account of the report of the Physical Research Division, under the direction of Dr. T. Theodorsen, which has been concerned for some time with the problem of flutter. Points of a detailed mathematical analysis are outlined and the necessary conditions for the occurrence of flutter are given.

Ackeret, J. and Studer, H. L. Bermerkungen über Tragflügelschwingungen. Helvetica Physica Acta, v. 7, no. 5, 1934. p. 501-504. (figures, references)

A preliminary series of experiments on a small scale for the investigation of wing oscillations. Observations of the displacement of the end of the wing when flutter occurs. Relationship between flutter and the angle of incidence immediately before oscillations commence (initial angle of incidence). Conclusions - the lag in the separation (boundary layer from upper or lower surface) with rapidly varying angle of incidence is responsible for flutter.

Bellomo, A. Le Vibrazioni Torsionali dell'Ala Monoplana a tutto Sbalzo. L'Aerotecnica, v. 14, no. 1, Jan. 1934. p. 27-39; no. 7, July. p. 854-869; no. 8-9, Aug.-Sept. p. 1030-1046; no. 12, Dec. p. 1414-1438; and v. 15, no. 3, March 1935. p. 276-298. (figures, tables, equations)

Jan. - Theoretical mathematical discussion of torsional vibrations of monoplane cantilever wings due to sudden variation of aerodynamical field around the wing. The hypothesis is that violent manoeuvre or squall bear the wing from incidence of zero aerodynamical twisting moment, in all sections around the elastic axis, to incidence for which such a moment is no longer equal to zero. July - Mathematical generalization of pure torsional vibrations of monoplane cantilever wing. Practical formulae for the calculation of maximum twisting deformation and of maximum dynamical torsional stress. (English abstract, p. 944) Aug.-Sept. - The problem is amplified by introducing the influence of internal damping. (English abstract, p. 1107) Dec. - Original theoretical study of torsional vibrations of monoplane cantilever wing caused by a gust of given intensity and direction. The value is given of the load factor for the torsion test of a wing structure. (English abstract, p. 1501) March 1935 - Numerical examples illustrating the use of the theories developed in preceding parts of this paper.

Cox, H. R. Problems Involving the Stiffness of Aeroplane Wings. Roy. Aero. Soc.-Jl., v. 38, no. 278, Feb. 1934. p. 73-107. (appendices, figures, tables, references, discussion)

Report attempts to determine what stiffness characteristics a wing structure should have if flutter is to be avoided and if the assumption of a rigid wing for determining aerodynamic load systems is sufficiently approximate. The investigations described indicate the imporance of providing high torsional stiffness in wings. Deals with torsional stiffness properties of conventional wings and the effect of providing high torsional stiffness on methods of strength calculation.

Duncan, W. J. Tail Buffeting. Roy. Aero. Soc.-Jl., v. 38, no. 278, Feb. 1934. p. 108-137. (figures, tables, references, discussion)

General account of investigations on buffeting conducted at the National Physical Laboratory. References to foreign work on the subject are also given. Description of apparatus used in experiments. Results of buffeting tests made with aerofoils of infinite aspect ratio, and buffeting in the wake of a wing-body combination. Influence of wind speed and of stiffness at constant incidence. Discusses devices for the prevention of buffeting.

Duncan, W. J., Ellis, D. L. and Gadd, A. G. Experiments on Servo-Rudder Flutter. British A.R.C., R. & M. No. 1652, Sept. 11, 1934. 30 p. (figures, tables, references)

Due to occurrences of flutter of servo-controlled rudders on full scale, it was decided to investigate this type of flutter on a model provided with a flexible fuselage. The investigation aimed at finding methods for preventing the flutter. Experiments carried out on one model, but a large number of factors affecting the flutter were varied. The principle ones were the elastic stiffnesses and inertial coefficients of the system. In a majority of cases flutter can be prevented by suitable mass loading of the main rudder and servo-flap. There are, however, certain unfavorable combinations of the elastic stiffnesses for which flutter prevention is difficult. Further developments are to investigate the case where the flap is geared so as to act as an aerodynamical balance for the main rudder which is directly operated.

Frazer, R. A. The Influence of Differential Aileron Control on Wing Flutter. British A.R.C., R. & M. No. 1723, Sept. 10, 1934. 20 p. (figures, equations, references)

The influence of differential aileron control on wing flutter recently came under consideration in connection with an investigation of the flutter characteristics of a model Puss Moth wing. The present report gives an account of the underlying theory. The dynamical equations obtained are appropriate to the standard case where the wing motions comprise normal flexure and twist. A few illustrative numerical applications are made based on data relevant to the Puss Moth wings. General conclusions.

Grossman, E. Tail Flutter. Central Aero-Hydrodynamical Inst., Moscow, Rep. No. 186, 1934. 98 p. (appendix, figures, tables, equations, references) (In Russian with brief English abstract)

Development of a method of determining critical flutter speed of an aeroplane tail unit. Problem treated theoretically, confined to two cases - four degrees of freedom and seven degrees of freedom. For the case of four degrees of freedom, the analysis is extended to design formulae and application. The first part of the work is confined to a study of inertial and aerodynamic forces and moments acting on the tail unit, and their variations due to flutter. Critical speed is determined from the equations of combined oscillations by the approximate method of Galerkin and from the condition of stability of motion. Illustrated by two numerical examples.

Klein, A. L. Effects of Fillets on Wing-Fuselage Interference. A.S.M.E.-Trans., v. 56, AER 56-1, 1934. p. 1-10. (figures, references, discussion)

Also Guggenheim Aeron. Laboratory (Pasadena) Tech. Rep. No. 18.

Discussion of the mutual interference of wing and fuselage. Preceding investigations have covered the case of a low-wing monoplane in which it was found that the addition of large fillets to the intersection of wing and fuselage would cause improvement. This investigation is extended to the case of a high-wing monoplane for comparison. Wind tunnel testing methods and results for both cases are given. A 1/6 scale model used. Rules for optimum fillet design. In the general discussion, buffeting is defined; its cause and effects on airplanes, as well as remedies, are described.

Lesh, L. Buffeting and Its Effects. Popular Aviation, v. 14, no. 6, June 1934. p. 367-368. (figure)

As a result of the accident in which Rockne was killed, tests for wing flutter and tail flutter with models, then with full size machines, were conducted. Effects of buffeting on a plane discussed.

Minelli, C. Velocità Critiche di Ala a Sbalzo a Longarone Unico. L'Aerotecnica, v. 14, no. 2, Feb. 1934. p. 123-148. (appendix, figures, equations, references)

Theoretical mathematical study of stability of variable chord wings of cantilever construction with single spar of variable torsional stiffness. Calculation of critical speeds. System of equations of three twisting moments. Numerical examples.

Minelli, C. Strutture Alari a due Longaroni con Centine. L'Aerotecnica, v. 14, no. 5, May 1934. p. 493-531. (figures, equations, references)

Investigation of the stiffness of 2-spar wings, both when unsupported and when fitted with external supports. Critical speed is calculated.

Minelli, C. Vibrazioni Flessionali Libere di Ali Sbalzo. L'Aerotecnica, v. 14, no. 12, Dec. 1934. p. 1371-1387. (appendix, figure, table, equations, references)

The problem is taken up of determining the frequencies in the free bending vibration of a cantilever wing possessing chord, mass, rigidity to bending, and elastic and aerodynamic damping distributed according to the parabolic law along the wing. The author calculates the frequencies by means of various combinations of values for the exponents of the parabola.

Ower, E. Note on Interference. Aircraft Engineering, v. 6, no. 62, April 1934. p. 93-96. (references)

Buffeting is briefly considered.

Pack, M. N. Flutter-Control Devices. A.C.I.C., v. 7, no. 689, July 10, 1934. 2 p. Air Corps Tech. Rep. No. 3875. (figures)

Purpose is to present suggestions for safety measures (damping devices), which can be installed on a new type airplane undergoing preliminary flight tests, in order to remove the possibility of destructive flutter.

Pugsley, A. G. Aileron Stability, with Special Reference to Rolling-Aileron Motion and the Influence of Frisé Type Hinge Moment Curves. British A.R.C., R. & M. No. 1595, Feb. 3, 1934. 29 p. (appendices, figures, tables, equations, references)

Describes theoretical investigations into the problem of aileron stability, with special reference to ailerons with Frisé characteristics. The problem is considered first by extending the conventional lateral stability theory to allow for an extra degree of freedom to represent aileron motion, and certain numerical results obtained on this basis are discussed. The theory of rolling aileron motion is given and is developed to derive conditions for aileron stability, critical speeds, and preventive measures. Incidental problems are noted in the appendices. Contains useful suggestions for the study of vibration problems in general.

Schmeidler, W. Mathematische Theorie des Schwingenfluges. Z.A.M.M., v. 14, no. 3, June 1934. p. 163-172. (equations, references)

Mathematical method for calculating the forces acting on an oscillating wing based on potential theory. Values obtained for lift, propulsion and power. The theory of an oscillating wing is developed in which the wing chord is at the same time assumed to be variable.

Schrenk, M. High-Speed Aircraft. N.A.C.A., Tech. Mem. No. 745, May 1934. 10 p. (figures, tables, references) Translated from Z.V.D.I., v. 78, no. 2, Jan. 13, 1934. p. 39-47.

Paragraph discussing "buffeting" at the tail surfaces. Americans did elaborate wind tunnel research on the use of an ingenious wing fillet. Such fillets prevent premature breakdown of flow at the wing contiguous to the fuselage at high angle of attack and thus avoid "buffeting". In the Heinkel HE 70, the wing roots are swept up slightly, and have a negative angle of incidence to remove the air-flow over the tail plane; it resulted in a 15 km/h higher speed.

Taylor, W. H. Some Studies on the Flutter of Airfoils and Propellers. A.S.M.E.-Trans., v. 56, AER 56-3, 1934. p. 57-64. (appendix, figures, equations, references, bibliography)

This paper is divided into three main parts: (1) a theoretical development of the deflection curve of a cantilever flat bar of uniform cross-section, by air forces distributed according to an elliptic-load grading curve, to show the effect of the warping produced by such loading in the strain energy of the bar so loaded; (2) an approximate solution of the free torsional vibrations of a cantilever bar of thin rectangular cross-section; (3) an analysis of the problem of self-induced torsional vibrations which will apply for any airfoil.

Theodorsen, T. General Theory of Aerodynamic Instability and the Mechanism of Flutter. N.A.C.A., Tech. Rep. No. 496, 1934. p. 413-433. (appendices, figures, tables)

Aerodynamic forces on an oscillating airfoil of three different degrees of freedom are determined. The theory is equivalent to the conventional wing section theory relating to the steady case. Analysis of the mechanism of aerodynamic instability. Flutter velocity is determined as a function of a certain ratio of the frequencies in the separate degrees of freedom for any magnitudes and combinations of the airfoil-aileron parameters. Numerical examples in appendices. Experimental results in appendix II.

Theodorsen, T. and Gelalles, A. G. Vibration Response of Airplane Structures. N.A.C.A., Tech. Rep. No. 491, 1934. p. 319-338. (figures, tables, references)

Test results of experiments on vibration-response characteristics of airplane structures on the ground and in flight. Also gives details of construction and operation of vibration instruments developed by the N.A.C.A. In ground tests, a study was made of the vibration response of fuselage, wings, and tail, by applying sinusoidal forces and couples at different parts of the fuselages of two planes. The measured and plotted amplitudes of vibration along the fuselage and wings at various frequencies and important natural modes of vibration were determined. In flight tests, vibration records were taken in the cockpits and tails of two planes. Vibrograms were analyzed and the amplitude of fundamental frequencies and most important harmonics plotted.

Tinsley, L. The Story of the Douglas D. C.'s. Popular Aviation, v. 15, no. 5, Nov. 1934. p. 285-286, 326-327.

One paragraph (p. 327) deals with tests of control flutter, control surfaces, and their supporting structures at high speeds vibrated by means of electrically driven oscillation machine.

Van Vliet, J. D. What About Wing Flutter? Popular Aviation, v. 15, no. 6, Dec. 1934. p. 371-373, 397. (figure, reference)

A graphical analysis of torsional vibration tests. In this article a prominent engineer carefully takes up the many causes that enter into wing flutter. This condition can be avoided by taking proper precautions in the design and construction of a wing.

Vellay, E. Les Vitesses Dangereuses pour les Ailes Sustentatrices. Assoc. Technique Maritime et Aeronautique, Bul. No. 38, 1934. p. 241-260. (discussion)

The critical speeds of vibration for airplane wings are determined.

White, J. A. and Hood, M. J. Wing-Fuselage Interference, Tail Buffeting, and Air Flow About the Tail of a Low-Wing Monoplane. N.A.C.A., Tech. Rep. No. 482, 1934. p. 143-161. (figures, references)

Experiments in the N.A.C.A. full scale channel. Tail buffeting due to the eddying wake of the wing roots. Trials made with different types of wing fuselage fillets, an N.A.C.A. cowling, a reflexed trailing edge next the fuselage, and auxiliary aerofoils in various combinations. The best results are obtained by a combination of cowling and fillet. Even without modifications, buffeting occurred only when the airscrew was not working.

____________ Investigation of Accident to Flying Boat, J-BCDO, "Sirohato". Aero. Res. Inst., Imp. Univ., Tokyo, Rep. No. 116, v. 9, no. 8, Jan. 1935. p. 195-437. (figures, reference) (In Japanese with English summary)

Accident attributed to the disconnecting of a turnbuckle on an aileron cable. It is supposed that the turnbuckle became unscrewed in bumpy weather, leaving the aileron free to oscillate, and that the subsequent fluttering of the wings produced rupture. Conditions of the accident were reconstructed in the laboratory and wind channel.

____________ Report on Puss Moth Accidents. British A.R.C., R. & M. No. 1645, March 6, 1935. 32 p. (appendices, figures, tables)

Inquiry into 9 accidents to the Puss Moth, a high-wing cabin monoplane, in which structural failure in the air has occurred. A Puss Moth aeroplane was used for special tests carried out at the Royal Aircraft Establishment. After discarding other possible causes, a final investigation was given to the study of conditions which might give rise to flutter. Rudder flutter was studied on a scale model of the tail organs and fuselage aft of wings. Wing flutter studied; a flexible scale model of wings was tested for wing flutter at the National Physical Laboratory. Wing flutter, possibly rudder flutter in some cases, gives satisfactory explanation of the accidents. Detailed technical investigations are described in separate memoranda, which will later be appended to this report. Each accident is briefly described. Examinations of available wreckage.

Blenk, H., Fuchs, D. and Liebers, F. Über Messungen von Wirbelfrequenzen. L.F.F., v. 12, no. 1, March 28, 1935. p. 38-41. (D.V.L. Report No. 35/01) (figures, references)

Investigation of the possibility of parts of an aeroplane being set up in vibration by the action of the vortices springing from the parts, or owing to their position in the vortex sheet of another part. Simple measurements at the D.V.L. by wind and water tunnel tests to ascertain the frequency of the vortices in the wake of bodies of different cross-section in dependence on the velocity and angle of incidence. Results. A summary comparison with English measurements (E. Tyler, Vortex Formation Behind Obstacles of Various Sections, Phil. Mag., April 1931).

Carey, R. Wing-Root Fillets. Flight, v. 27, no. 1370, March 28, 1935. p. 332d-332e. (figures)

Interference set up at the junction of wing and fuselage causes violent buffeting of the tail due to the eddying from the wing root. This effect is due to premature breakdown of the flow of air at the wing and fuselage surfaces. The use of wing fillets in solving this problem is discussed. Obtaining the Venturi-tube effect with wing fillets.

Falkner, V. M. The Effect of Variation of Aileron Inertia and Damping on the Flexural-Aileron Flutter of a Typical Cantilever Wing. British A.R.C., R. & M. No. 1685, Oct. 17, 1935. 12 p. (figures, tables, references)

The present work forms part of an investigation on methods of flutter prevention, dealing with a dead-center aileron control on a flexible model Puss Moth wing. It treats also the use of mechanical devices for artificially increasing aileron damping and moment of inertia. Calculations have been made of the critical flexural-aileron flutter speeds of a cantilever wing, with a reversible aileron control of the usual type, of which the characteristics have been chosen to represent current practice, as applied to high speed aircraft.

Falkner, V. M., Jones, W. P. and Scruton, C. Flutter Experiments on a Model Wing Fitted with a Dead-Center Aileron Control. British A.R.C., R. & M. No. 1686, Oct. 17, 1935. 10 p. (figures, table, references)

Tests to find the effect, as a preventative of wing flutter, of an aileron control having a dead-center at the neutral position. Critical wind speeds for flutter were observed over a range of aileron angles for conditions: (1) with a dead-center aileron control; (2) using three different "pilot control" springs; (3) with a reversible control of the normal type, mainly with one "pilot control" spring. Supplemented by calculations of the critical flutter speeds, with control column locked, of a typical cantilever wing, fitted with a range of dead-center aileron controls, defined by a simple law.

Falkner, V. M., Jones, W. P. and Scruton, C. The Effect of a Reduction of Aileron Torsional Stiffness on the Flutter of a Model Wing. British A.R.C., R. & M. No. 1722, Oct. 17, 1935. 8 p. (figures)

The purpose of the tests was to find the quantitative influence of a reduction of aileron torsional stiffness on wing flutter. The wing used was the flexible model Puss Moth wing described in R. & M. No. 1699, but with certain modifications to the aileron and control system. Critical flutter speeds were measured firstly with the aileron torsional stiffness roughly twice that corresponding to the full-scale Puss Moth aileron (as for structural condition no. 5 of R. & M. No. 1699). The tests were repeated with the torsional stiffness reduced to about 40%. For each value of the torsional stiffness the flutter speeds were obtained for a variety of mass loading conditions of the aileron and with several different mass balance systems fitted. Conclusions.

Grzedielski, A. and Seredynski, R. L'Application des Equations Intégrales à la Statique d'Avion. Instytut Badan Technicznich Lotnictwa, No. 1 (16), Rep. No. 64, 1935. p. 5-43. (figures, tables)

Calculation of the curvature undergone by a spar subjected to bending and in compression, of the torsion angles of the wing and of the period of the natural oscillation. Difficulties of the problem, as far as the theory is concerned, have already been overcome, but the methods are too complicated for practical use. With a view to evolving a method useful to designers, research was undertaken at the Instytut Badan Technicznich Lotnictwa. Results of this research given embodying the method, a method of integral equations.

Jarry, M. Sur les Interactions Aérodynamiques. Journées Scientifiques et Techniques de Mécanique des Fluides, v. 1, 1935. p. 139-221. (figures, bibliography, discussion)

The interactions of various elements in an airplane may considerably influence the performance and in certain cases produce dangerous vibrations or flutter. Various phases of the phenomena are discussed, and the influence on different parts of an airplane considered. The author considers experiments in a tunnel as giving more complete and systematic data than the existing theories.

Levy, M. Etude des Vibrations des Ailes par les Equations de Lagrange. Science Aérienne, v. 4, no. 5, Sept.-Oct. 1935. p. 316-345. (figures, bibliography)

Consideration of many types of wing vibrations, the most important among them being the deflexion-torsional type because of the difficulty of eliminating it. This is a qualitative study of deflexion-torsional vibration resulting in new contributions to the classical theory of vibrations such as the fact that this kind of vibration may appear at very great speeds even if the center of gravity is on an elastic axis. The equations of motion are found. In developing these equations it is shown that there exists a critical speed above which vibrations increase progressively and produce rupture of the parts. A study of the influence of high speeds on dangerous vibration follows.

Risack, M. Vibrations Couplées des Ailes d'Avion. Service Technique de l'Aeronautique, Bul. No. 16, April 1935. p. 1-56. (figures)

Investigation of the motion resulting from a disturbance causing, by bending and torsion, displacement of the wing out of its original position equilibrium, which ceases to act, the forces set in action being then no longer statically balanced. Equations of motion during the disturbance derived and the theory developed for the general case of a damped disturbance for any velocity. A more complete study determining the limit velocity below which damping of the disturbance is ensured. An experimental method for determining the coefficients is given and their influence discussed. An example of application to a wing. Theory extended to the case of aileron oscillations superposed on bending and torsion of the wing.

Riz, P. The Resonance Method of Determination of the Natural Frequency of Airscrew Blades. Central Aero-Hydrodynamical Inst., Moscow, Rep. No. 242, 1935. 28 p. (figures, tables, references) (In Russian with a brief English abstract)

A brief description of the resonance method of determining the natural frequency of airscrew blades given. Correction formulae are developed for the conversion of the natural frequency of a freely rotating airscrew to that of a fixed airscrew. A comparison of the theoretical with the experimental data is made. In an appendix the effect of aerodynamical forces on the frequency of flexural oscillations of rotating airscrew blades is determined and is found to be practically negligible as compared with centrifugal force.

Schmeidler, W. Dynamik des Schwingenfluges. L.F.F., v. 12, no. 4, July 30, 1935. p. 128-133. (figures, references)

Approximation formulae for forward propulsion and lift in case of ornithopter, enabling any conditions of flapping motion to be postulated, use being made of the concept of periodically variable wing chord, as well as the angle of incidence. Wind tunnel tests on models. Simple formula for efficiency of the ornithopter. Method for design.

Stitz, W. E. Vibration Characteristics of Twenty Air Corps Airplanes. A.C.I.C., v. 8, no. 702, Sept. 1, 1935. 4 p. Air Corps Tech. Rep. No. 3975. (table, references)

Airplane structures are subject to resonant vibrations from forces generated by rotating engine parts and from cylinder explosion impulses. Means given for the prevention or elimination of the buffeting type of surface vibration, prevention of flutter and its relation to dynamically balanced surfaces, and prevention of resonant structural vibration due to engine forces.

Vairano, C. Sopra un Caso di Integrabilità delle Equazioni delle Vibrazioni Flessionali delle Ali a Sbalzo. L'Aerotecnica, v. 15, no. 9-10, Sept.-Oct. 1935. p. 938-943. (equations)

Equation of transverse vibrations of a wing (considered as a clamped beam) developed, taking into account internal damping and air resistance. Separation of variables possible on supposition that the ratio of mass loading to resistance coefficient-constant along the wing. If the mass and moment of inertia vary along the wing exponentially, an elementary solution is possible.

____________ Perforated Flaps. Aviation, v. 35, no. 5, May 1936. p. 37.
Also Aeroplane, v. 50, no. 1308, June 17, 1936. p. 767.

First full-scale application of perforated flaps designed to prevent tail buffeting by diffusing or breaking up irregularities of the wake of a wing. The Northrop attack plane is equipped with these flaps. No test data is available, but preliminary report indicates that the cutaway areas are about as effective as flaps as the solid type.

v. Borbely, - Mathematischer Beitrag zur Theorie der Flügelschwingungen. Z.A.M.M., v. 16, no. 1, Feb. 1936. p. 1-4. (figures, equations, references)

Mathematical discussion of the theory of vibrating airplane wings, by the method of Bessel functions.

Cicala, P. Ricerche Sperimentali sulle Vibrazioni Flesso-Torsionali di un Modello di Ala con Rigidezze Variabili. Atti della Reale Accademia delle Scienze di Torino, No. 34, v. 71, 1936. p. 554-579.

This report gives the result of a series of model wing tests which included determination of the critical velocity, frequency and form of the oscillation for various values of flexural and torsional rigidities. The tests showed the well-marked influence of the angle of incidence on the critical velocity and the noteworthy difference in the period and form of the oscillations arising with the two conditions of with and without wind.

Cicala, P. Le Azioni Aerodinamiche sul Profilo Oscillante. Atti della Reale Accademia delle Scienze di Torino, No. 85, 1936.

A summary review of the stage reached in research of the aerodynamic field about a wing in vibration is made and this is followed by the exposition of a method for the solution of the problem and of the results yielded by the theory.

Cicala, P. Le Oscillazioni Flesso-Torsionali di un Ala in Corrente Uniforme. Atti della Reale Accademia delle Scienze di Torino, No. 92, 1936. (figures, equations) Also L'Aerotecnica, v. 16, no. 11, Nov. 1936. p. 785-801.

The conditions of stability in respect to flexural-torsional oscillations of a wing of finite span being determined, a graphical process for the determination of the critical velocity, of the oscillation frequency and of the amplitude and phase ratios of the component motions is described. The results are compared with those obtained in the Turin experiments. A graph is given for the rapid calculation of the critical velocity.

Dearborn, C. H. and Soulé, H. A. Full-Scale Wind-Tunnel and Flight Tests of a Fairchild 22 Airplane Equipped with a Fowler Flap. N.A.C.A., Tech. Note No. 578, Aug. 1936. 19 p. (figures, table, references)

Full-scale wind-tunnel and flight tests were made of a Fairchild 22 airplane equipped with a Fowler flap, to determine the effect of the flap on performance and control characteristics of the airplane. During the course of tests, it was noted that tail buffeting, present with all flaps previously tested on this airplane, was greatly lessened with the Fowler flap. This flap extended across the center section, whereas previous flaps had a 3-ft. cutout at this point. Apparently, the slot between the flap and the wing tends to reduce the turbulence in the flap wake that strikes the tail at certain angles of attack, and is believed to be the cause of the buffeting.

Duncan, W. J., Collar, A. R. and Lyon, H. M. Oscillations of Elastic Blades and Wings in an Airstream. British A.R.C., R. & M. No. 1716, Jan. 10, 1936. 38 p. (appendix, figures, tables, equations, references)

Objects of the paper are to develop a method for the theoretical treatment of the oscillations of blades and wings in an air current; to use this method to check the correctness of the current "semi-rigid" theory; and to make detailed applications to a class of solid tapered blades.

Hunt, W. E. Spinning and Tail Buffeting Tendencies and Means by Which They can be Detected and Suppressed on Complete Scale Model in Wind Channel. Aeronautical Sciences-Jl., v. 3, no. 12, Oct. 1936. p. 444-447. (figure, tables)

Reports on tests by Crouch- Bolas Aircraft Corp. to ascertain stability both longitudinally and in yaw relative to anti-spinning tendencies. Study of tail buffeting and its prevention.

Kassner, R. Die Berücksichtigung der inneren Dämpfung beim ebenen Problem der Flügelschwingung. L.F.F., v. 13, no. 11, Nov. 20, 1936. p. 388-390. (figures, references)

Graphical process developed for the calculation of the two-dimensional problem of wing oscillation account being taken of internal damping.

Kassner, R. and Fingado, H. Das ebene Problem der Flügelschwingung. L.F.F., v. 13, no. 11, Nov. 20, 1936. p. 374-387. (figures, table, references)

Küssner's work has made the calculation of wing oscillations possible in principle. Restricting considerations to the two-dimensional problem, the authors have developed an exact method of calculation, simple, and thus suitable for the designer, with which the exact calculation of the critical velocity can be effected for wings without flaps and without internal damping, by means of a nomogram. Examples calculated by the method are used to derive certain principles for the design of good wings from the point of view of the oscillation theory.

Küssner, H. G. Status of Wing Flutter. N.A.C.A., Tech. Mem. No. 782, Jan. 1936. 50 p. (figures, tables, references) Translated from L.F.F., v. 12, no. 6, Oct. 3, 1935. p. 193-209. (D.V.L. Rep. No. 35/17)

Survey of previous theoretical and experimental investigations on wing flutter, covering 13 cases of flutter, observed on airplanes. The direct cause of flutter is, in most cases, attributable to (mass) unbalanced ailerons. Under conservative assumption that the flutter with the phase angle most favorable for excitation occurs only in two degrees of freedom, the lowest critical speed can be estimated from data obtained on oscillation bend. Corrective measures for increasing critical speed and for definite avoidance of wing flutter discussed.

Minelli, C. Indagini sulle Vibrazioni dei Velivoli. L'Aerotecnica, v. 16, no. 5, May 1936. p. 340-347.

Study of aircraft vibrations undertaken at the experimental laboratories in Guidonia. For the present, the study follows purely theoretical lines restricted to limited types of vibration phenomena, such as flexural-torsional, torsional-aileron, flexural-aileron. This article is the first of a series. The case of torsional-aileron vibrations presented takes into account the effect of distributed weight along the wing span. Criteria developed for torsional dynamic stability of the wing structure and the dynamic equilibrium of the aileron. The next article will treat the case of flexural-aileron vibrations.

Minshall, R. J., Ball, J. K. and Laudan, F. P. Problems in the Design and Construction of Large Aircraft. S.A.E. Preprint for Meeting, Oct. 15 to 17, 1936. 22 p. (figures)

Aerodynamic, structural and manufacturing problems in the design of the larger aircraft with reference to Boeing practice. Selection of airfoils, flutter and flight control are briefly reviewed. Structural design considerations are examined in detail.

Pugsley, A. G. The Wing Stiffness of Monoplanes. British A.R.C., R. & M. No. 1742, Nov. 1936. 16 p. (appendices, figures, tables)

A concise review of the subject of wing stiffness from the design standpoint. Notes on a standard procedure for the measurement of wing stiffness and an analysis of the wing stiffnesses of actual monoplanes are appended. Brief references throughout to the relationship between wing stiffness and flutter.

Rauscher, M. Flutter. IV Parts. Aviation, v. 35, no. 1, Jan. 1936. p. 20-22; no. 2, Feb. p. 26-29; no. 4, April. p. 18-20; no. 5, May. p. 27-29. (figures)

Part I - Emphasizes the simplicity of the physical principles involved in flutter. Discusses the general characteristics of flexural-aileron flutter, ternary flutter and externally braced wings, etc. Remedies given to avoid these types of flutter.
Part II - Treats the causes and cures for flutter of cantilever wings, tail surfaces, and servo controls.
Part III- Considers certain theoretical and practical aspects of the problem of balancing.
Part IV - Derives formulae for balancing coefficients and makes some practical suggestions relating to flight test technique.

Rauscher, M. Model Experiments on Flutter at M.I.T. Aeronautical Sciences-Jl., v. 3, no. 5, March 1936. p. 171-172. (figures, references)

Treats the problem of flexural-torsional flutter and covers a part of the intended investigation of the complete theory of flexural-torsional-aileron flutter. Tests were conducted with an airfoil, in which the mass center of gravity location, moment of inertia, and rigidities were variable in wide limits. The tests were made in the presence of a fuselage. The dependence of critical flutter speed on angles of attack and the effects of flexural stiffness, mass and c.g. location, as well as the natural frequency ratio on flexural-torsional flutter illustrated.

Relf, E. F. Modern Developments in the Design of Aeroplanes. Inst. of Civil Engrs. (G.B.)-Jl., v. 3, no. 8, Oct. 1936. p. 523-566. (figures, references)
Also Engineer, v. 161, no. 4191, May 8, 1936. p. 481-483. (discussion p. 491)
Engineering, v. 141, no 3669, May 8, 1936. p. 513-515; no. 3671, May 22. p. 572-573. (discussion - v. 141, no. 3672, May 29, 1936. p. 589-590)
Aircraft Engineering, v. 8, no. 88, June 1936. p. 163-166; no. 89, July. p. 185-190.

Discussion of new development in aircraft design; improvement due to better aerodynamic design. Some attention paid to flutter and the need for further consideration due to increases in flying speeds. Desirable feature is a wing very stiff but at a cost of more weight than is necessary. Another consideration demanding great torsional rigidity of wings is efficiency of aileron control. Opportunity for research, present and future, in aircraft operation and aerodynamic design. The general problem of oscillations of dynamical systems obeying non-linear laws, so that knowledge gained can be applied to flutter problems arising in high-speed aircraft.

Richard, P. and Richard, M. Les Phénomènes Dynamiques dans les Voilures. L'Aerophile, v. 44, no. 1, Jan. 1936. p. 7-9; no. 2, Feb. p. 38-40. (figures, equations)

The influence of elasticity on the nature of the vibrations and their development in airplane wings. Three cases considered: (1) wing mounted on a fixed spindle around which it may oscillate elastically; (2) a wing flexible in bending and torsion; (3) a wing flexible in bending and torsion and equipped with a normal aileron. Loss of stability by divergence and buffeting explained.

v. Schlippe, B. The Question of Spontaneous Wing Oscillations. (Determination of Critical Velocity Through Flight-Oscillation Tests). N.A.C.A., Tech. Mem. No. 806, Oct. 1936. 10 p. (figures)
Translated from L.F.F., v. 13, no. 2, Feb. 20, 1936. p. 41-45.

Determination of spontaneous oscillations of a wing or tail unit entails many difficulties, both the mathematical determination and determination by static wing oscillation tests being far from successful and flight tests involving very great risks. Report gives the method developed at the Junkers Airplane Co., by which critical velocity with respect to spontaneous oscillations of increasing amplitude can be ascertained in flight tests without undue risks, the oscillation of the surface being obtained in tests by application of an external force. The method was evolved in the wind tunnel but has been successfully tested in actual flight. It is still in the course of development.

Sezawa, K. The Nature of Wing Flutter as Revealed Through Its Vibrational Frequencies. Aeronautical Sciences-Jl., v. 4, no. 1, Nov. 1936. p. 30-34. (figures, equations, references)

With a view to determining the nature of flutter as accurately as possible, analytical experiments were made, using a model so simple that the elements of that model in vibration were reduced to such an extent that a quantitative calculation for predicting flutter could be made beforehand. A general view of the device used in the study, by means of which experiments with any type of vibrations, whether of the type of deflection-aileron, torsion-aileron, deflection-torsion, or even of deflection-torsion aileron, could be conducted.

Sezawa, K. and Kubo, K. The Nature of the Torsion-Aileron Wing Flutter as Revealed by Analytical Experiments. Aero Res. Inst., Imp. Univ., Tokyo, Rep. No. 136, v. 11, no. 4, Feb. 1936. p. 105-161. (figures, tables, equations, references) (In English with brief Japanese abstract, p. 105-106)

Object of the investigation was the study by means of model experiments of the torsion-aileron flutter of a wing. A mathematical investigation was also carried out. Flutter appears to be due partly to instability in the free oscillations of the wing and partly to resonant vibrations. These are particularly liable to occur at a wind velocity corresponding to neutral stability of the free oscillations.

Sezawa, K. and Kubo, S. The Nature of the Deflection-Aileron Flutter of a Wing as Revealed Through Its Vibrational Frequencies. Aero. Res. Inst., Imp. Univ., Tokyo, Rep. No. 140, v. 11, no. 8, June 1936, p. 301-338. (figures, tables, equations, references)

Object of the investigation was to study deflection-aileron flutter of a wing by means of model experiments and mathematical prediction. The character of flutter ascertained through its vibrational frequency and amplitudes at any wind velocity. Results show that resonance forced vibrations of selective type prevail in the upper half of wind velocities. Conclusions - precautions, necessary to be taken, demand increase in stiffness of spars, besides balancing of the aileron mass in the product as well as in the moments of inertia, and also stiffness of the control cables.

Studer, H. L. Experimentelle Untersuchungen über Flügelschwingungen. Mitteilungen aus den Institut für Aerodynamik. Eidgenössische - Technische Hochschule, Zurich, No. 4/5. 1936. 98 p. (figures)

The investigations of wing flutter forming the subject of this report throws light on the differences between the two forms of oscillations, the Birnbaum oscillation and the "breakaway" oscillation recently identified and ascribed to the presence of an aerodynamic hysteresis effect. Several recommendations are derived from the results of the tests with regard to the reduction of the liability to wing flutter.

Tuckerman, L. B. and Ramberg, W. An Interesting Case of Sub-multiple Resonance. Amer. Phys. Soc.-Proc., Washington Meeting, April 30 - May 2, 1936. (references)

Investigation into a case of severe vibrations in an airplane shows that air impulses from a two-blade propeller (frequency of 3200 per min.) excites resonant vibrations in the wings (1600 cycles per min.) which in turn excites resonant vibrations in the tail assembly (800 cycles per min.) Natural frequencies of wing and tail differ enough from the ratio 2 to 1 to produce strong beats by interchange of energy between wing and tail. Submultiple resonance is possibly the unrecognized cause of undue vibrations.

Victor, M. Les Vibrations de Résonances. Les Ailes, Jan. 30, 1936. p. 5.

The 3 kg. Rouy brake attached to the wings of a 4-ton airplane is said to dampen resonance vibrations. This device and a similar one for damping aileron vibrations are described in connection with a long explanation of resonance vibration and its occurrence in airplanes. Torsion vibration of engines is also discussed. It is concluded that in each wing profile there is a different critical speed of continuous beating of the wing and aileron.

Ananiev, I. B. Proper Frequencies of Vibrations of the Wing and Tail Surfaces of Aircraft. Central Aero-Hydrodynamical Inst., Technic of the Air Fleet, No. 1, Jan. 1937. (In Russian)

Paper is intended to furnish a comprehensive method of determining frequencies of vibrations of wing and tail surfaces of a new design. Scientific accuracy is somewhat sacrificed for expediency. The method is primarily intended as an engineering tool.

Cicala, P. Ricerche Sperimentali sulle Azioni Aerodinamiche sopra l'Ala Oscillante. L'Aerotecnica, v. 17, no. 5, May 1937. p. 405-414. (bibliography)

Theoretical discussion and results of tests made at the Aeronautical Laboratory of Turin, Italy, relating to the determination of moments due to vibrations of wing profile.

Lemaire, P. Les Etouffeurs Dynamiques de Vibrations. Science Aérienne, v. 6, no. 1, Jan.-Feb. 1937. p. 7-22. (figures, equations, references)

The author treats mechanical problems according to electrical theory and makes use of Ohm's laws. After an explanation of his theory of the vibration absorber, the author explains that absorbers with damping devices, while diminishing the amplitude of oscillations, may enlarge the field of possible vibrations. This absorber, which has no damping device, may be used to advantage for the damping of airplane wing vibrations.

Pugsley, A. G. Wing Flutter. Roy. Aero. Soc. Meeting Paper, April 8, 1937.

Outline of past and present problems of wing flutter. Remedies which may be found to be practical in which case the necessary wing stiffness in torsion may be obtained without a great deal of extra wing weight. Methods of attaining a mass-balanced condition with the conventional type of wing.

Sezawa, K., Kubo, S. and Miyazaki, H. Vibration Phenomena in Ternary Wing Flutter. Aero. Res. Inst., Imp. Univ., Tokyo, Rep. No. 147, v. 12, no. 3, April 1937. p. 131-162. (figures, tables, equations, references)

This paper is an extension of the two preceding papers to a more general case of ternary flutter, including the special case of binary and unitary flutters. The models used in the experiments were of the U.S.A. 35A type, which is the same as one of those discussed in the preceding papers, the incidence angles, however, being restricted to certain negative ones. It was confirmed that even should the details with respect to the wing and the aerodynamic force differ, every vibrational condition excepting the amplitude distribution can be uniquely determined provided the constants $A_1/A_0$ $A_2/A_0$......$A_6/A_0$ are the same, the vibrational frequencies and damping coefficients of the model being consequently the same as the full scale wing. In the present investigation the character of the flutter was ascertained, mathematically and experimentally, through its vibrational frequencies and amplitudes for any wind velocity. The fact that the flutter is a condition of unstable vibration, but not a resonance phenomenon due to turbulence of the wind was confirmed by comparing the mathematical solution of the free and forced vibrations.

Yamamoto, M. and Suzuki, Z. On the Natural Vibration of Semi-Cantilever Beam with One End Fixed or Pin-jointed. Aero. Res. Inst., Imp. Univ., Tokyo, Rep. No. 149, v. 12, no. 5, May 1937. p. 319-335. (figures, references) (In Japanese with brief English abstract)

The natural vibration of the semi-cantilever beam having uniform section which is fixed at one end, free at the other and supported at the intermediate point is studied. Also the effects of the position and elasticity of the intermediate support, and the axial force in the inner bay are investigated in the general case, and compared with the case of a beam with one end pin-jointed, the latter case without axial force in the inner bay having been studied by J. Morrow. The modes of vibration of such beams in fundamental tone, and also first, second, and third harmonics are calculated for a special wing spar as an example. The effect of the friction in the intermediate support and pin-jointed end on the vibration frequency is studied by a simple model experiment. Conclusions.

PROPELLER VIBRATION

O'Gorman, M. Report on the Precautions Taken as to the Strength of Details on the B.E. Class of Aeroplanes. British A.R.C., R. & M. No. 127, May 1914. 45 p. (appendices, figures, tables)

Report deals solely with the strength as distinct from the aerodynamic value of the various items of detail which make up the aeroplane B.E. 2. Included is a discussion on vibration from airscrews. Description of a test to secure safety of an airscrew blade from vibration. Use of multiple blades eliminates gyroscopic vibration from an aeroplane and is considered superior for B.E. 2.

______________ Report on the Fracture of a Propeller Shaft. British A.R.C., R. & M. No. 215, July 1915. 6 p. (figures)

Discussion of fracture due to fatigue. It was established that the period of the alternating forces, due to interference between propeller blades and testing bed, was the same as the period of the shaft in bending. Forces due to this interference considered sufficient to maintain the amplitude necessary to cause fatigue fracture. Considerations of interest are the amplitude of oscillation necessary to produce high stresses, damping and the presence of a periodic forcing couple. Methods of avoiding such resonance are suggested.

Lanchester, F. W. and Jones, B. M. Gyroscopic Action and Propeller Vibration. British A.R.C., R. & M. No. 185, Jan. 1915. 2 p.

Summary of notes on gyroscopic action of an airscrew, and the vibrations set up by a two-bladed airscrew, in an aeroplane when turning. Brief mathematical summary given of the points considered.

Fage, A. The Whirling and Transverse Vibrations of a Rotating Airscrew and its Shaft. British A.R.C., R. & M. No. 502, June 1917. 15 p. (figures, tables)

General mathematical theory of transverse vibrations of a rotating airscrew and its shaft. Applications of Lagrange's equations for small oscillations. Calculations for a two-bladed airscrew, when the transverse vibrations are in a plane parallel to both the axis of the airscrew blades and the axis of rotation, and when in a plane at right angles to the axis of the airscrew blades and parallel to the axis of rotation. General conclusions are given. The formula for calculating the whirling speed of an airscrew and its shaft presented.

Berry, A. On the Vibrations of a Uniform Rod Rotating Uniformly about One End, which is Encastré. British A.R.C., R. & M. No. 488, Sept. 1918. 6 p.

Theoretical analysis is presented to throw light on the question as to whether the vibrations of an airscrew blade are materially affected by the centrifugal force.

Cowley, W. L. and Levy, H. Critical Loading of Struts and Structures. Part VI - Effect upon Vibration and Strength of a Strut or Spar due to Variation along the Bay of Longitudinal Thrust, Flexural Rigidity and Mass per Unit Length. British A.R.C., R. & M. No. 566, Nov. 1918. 12 p.

The general problem is treated of vibration and crippling of a beam under end thrust and simply supported when rigidity mass per unit length and end thrust varies along the bay. Two methods are given. The vibration of propeller shafts and blades and similar problems can be solved by these methods. Other applications are given.

Griffith, A. A. Formula for Calculating the Vibration Speeds of Propellers. British A.R.C., R. & M. No. 451, June 1918. 6 p.

Simplification of the method in use at the time. Formula derived from the general equation for calculating vibration speeds which yields the critical speed by direct substitution of the sectional areas and moments at 5 points along the blade. For well-designed blades, results (with formula) are within 2%, but when the design is carried out without reference to torsional properties, they are too high.

Griffith, A. A. and Hague, B. Second Report on the Twisting of Propeller Blades. British A.R.C., R. & M. No. 455, Feb. 1918. 10 p. (figures)

Mathematical interpretation of a method of investigating the twist of propeller blades (developed in R. & M. No. 454) by making certain assumptions as to shape of the cross-sections. It is shown that blades of certain shapes may be peculiarly liable to torsional vibration, and that the maximum stress due to torsion may determine fracture in this case. Discussion of the effect of large torsional hysteresis of timber in damping out vibrations. Suggestions for modification of current practices in accordance with present theory.

Griffith, A. A. and Hague, B. On the Shape of Propeller Blades. British A.R.C., R. & M. No. 452, June 1918. 13 p. (figures)

Article deals with design of propeller blades as affected by their elastic properties and shows that the best type of blade, from stress standpoint, is one in which transverse vibrations involve practically no torsion. The standard method of stressing and designing propeller blades is reviewed in light of theory put forward in R. & M. Nos. 454-455. Examples and experiments given.

Southwell, R. V. Note on Mr. Griffith's Formula for Calculating the Vibration Speeds of Propellers with a Solution for the Frequencies of Vibration in a Rotating Heavy String. British A.R.C., R. & M. No. 483, Aug. 1918. 4 p.

Further development of work done in R. & M. No. 451. A solution obtained for the frequencies of vibration in a rotating heavy string, and also a formula for the fundamental frequencies.

Webb, H. A. and Swain, L. M. Vibration Speeds of Airscrew Blades. British A.R.C., R. & M. No. 626, May 1919. 10 p. (figures)

Investigation to obtain some estimate of the effect of centrifugal force on vibration speeds of airscrews. Mathematical solution of problem in the case of the knife-edged wedge which is compared to Berry's solution for the rod, as it is thought possible to consider an airscrew intermediate to these. A curve is obtained for the correction due to centrifugal force, which should give results not more than 2% in error for practical airscrews at their ordinary running speeds, assuming that the vibrating speed for an airscrew blade, when centrifugal force is neglected, is found by Griffith's method (R. & M. No. 451).

Southwell, R. V. and Gough, B. S. On the Free Transverse Vibrations of Airscrew Blades. British A.R.C., R. & M. No. 766, Oct. 1921. 12 p. (tables)

Theoretical investigation of the natural frequencies of transverse vibration for a bar of given shape, when this rotates in vacuo about an axis through one end, and one principal axis of every cross-section is parallel to the axis of rotation.

Morris, J. The Vibration of Airscrew Blades. Roy. Aero. Soc.-Jl., v. 26, no. 144, Dec. 1922. p. 472-475. (figures, equations)

An attempt to ascertain mathematically whether flexible properties of blades give rise to undesirable effects. The equation of motion is calculated for a rod encastréd at one end and oscillating in one plane. Mathematical investigation of the effect of centrifugal force on airscrew blades. The frequency of the "flutter" of airscrew blades considered.

Fage, A. An Experimental Study of the Vibration in the Blades and Shaft of an Airscrew. British A.R.C., R. & M. No. 967, Sept. 1925. 16 p. (figures, tables)

Investigation of natural frequencies of flexural vibration of blades and shaft of a rotating airscrew determined from an analysis of sounds emitted. Comparison of the theoretical with the experimental results. Experiments made on four airscrews of different blade shape, the variables of design being width and geometrical pitch. Analysis of results.

Southwell, R. V. Some Recent Work of the Aerodynamics Department, National Physical Laboratory. Roy. Aero. Soc.-Jl., v. 29, no. 172, April 1925. p. 146-167. (figures, discussion)

Comprehensive survey of the work of the aerodynamics department. Includes brief discussion of elastic vibrations. Refers to the results of experiments on modes of vibration. Also discusses airscrew vibrations. Apparatus for experiments on vibrations of airscrew described graphically.

Carter, B. C. and Swan, A. Torsional Vibration. Automobile Engineer, v. 16, no. 213, March 1926. p. 86-88. (figure)

Notes in connection with crankshaft-airscrew systems. Enumeration of the general conclusions reached regarding multi-crank engines, and outlines of a simple method of determining frequency of natural vibration in particular cases.

Morris, J. Airscrew Vibration and Gear Stripping. Roy. Aero. Soc.-Jl., v. 30, no. 188, Aug. 1926. p. 495-502. (figures)

Mathematical treatment of airscrew vibration and stripping. Conclusions reached are that for the two-bladed airscrew there is danger of failure resulting from gear action; for four-bladed airscrew resonance occurs in the useful range of speed through blade interference, and in case of two-bladed airscrew through gear action.

Younger, J. E. Preliminary Study of Fatigue Failures of Metal Propellers Caused by Engine Impulses and Vibrations. A.C.I.C., v. 7, no. 618, Aug. 15, 1928. 17 p. Air Corps Tech. Rep. No. 2870. (appendices, figures, tables)

Periodic torque impulses and transverse vibration of the engine investigated as cause of failure in propellers. Formulae developed and methods suggested for efficient and practical use in routine design and tests of metal propellers. Processes involved in vibration problems are made clear and results available for general use. Mathematical processes discussed in appendices. Investigation was undertaken as result of breakage of propeller No. X - 49975 while in flight.

____________ Metal Propellers To-Day. Aircraft Engineering, v. 1, no. 7, Sept. 1929. p. 261. (figure)

Some constructional details given of the Leitner Watts propeller; the material is steel and blades are hollow. The blades are hollow because only thus can excessive weight be avoided, and at the same time both flexural and torsional rigidity be maintained. It is claimed that the phenomenon of flutter, so common with all other airscrews, has never been observed with hollow steel blades.

Lynam, E. Notes on the Flutter of Airscrew Blades. British A.R.C., R. & M. No. 1258, April 1929. 5 p. (figures)

Summary of practical experience of airscrew flutter, chiefly on wooden screws. Full scale experiments described. Minimum safe thickness and chord ratios for mahogany blades specified.

______________ Propeller Balancing Equipment. Aero Digest, v. 16, no. 6, June 1930. p. 118. (figures)

Description of propeller balancing device. By applying this device, the power of engine improves greatly and vibrations are avoided because a better balance can be obtained.

Brunelli, P. E. La Velocità Critica degli Alberi Porta-Elica. Notiziario Tecnico di Aeronautica, v. 6, no. 3, March 1930. p. 219-229. (figures, tables)

Brief review of the known solution for critical speed of propeller shafts, and description of new method permitting more complete solution.

Jennings, W. G. and Ormerod, A. Full Scale Experiments on High Tip Speed Airscrew; The Effect of Thickness of Section on Airscrew Performance. British A.R.C., R. & M. No. 1339, Aug. 1930. 6 p. (figures, table)

This report shows that a decided gain in efficiency results from use of very thin sections when the tip speeds approach the velocity of sound. Experiments also show that flutter occurs at approximately the same tip speeds for full scale and model airscrews of the same material. Performance tests: full scale comparative tests of airscrews with different thickness/chord ratios.

Liebers, F. Contribution to the Theory of Propeller Vibrations. N.A.C.A., Tech. Mem. No. 568, June 1930. 23 p. (figures)
Translated from Zeit. Tech. Phys., v. 10, no. 9, 1929. p. 361-369.

Calculation of the torsional frequencies of revolving bars with allowance for the air forces. Calculation of the flexural or bending frequencies of revolving straight and tapered bars in terms of the angular velocity of revolution. Calculation on the basis of Rayleigh's principle of variation. Error estimation and the accuracy of the results. Application of the theory to screw propellers for airplanes and the liability of propellers to damage through vibrations due to the lack of uniform loading.

______________ A Flexible Propeller Hub. Scientific American, v. 144, no. 2, Feb. 1931. p. 124. (figure)

This flexible propeller hub was designed to avoid torsional vibration. The propeller is driven by means of radial spring arms, the central boss of the arms being keyed to the shaft in the usual way. This reduces the stiffness of the system, slows down the period of oscillation, yet at the same time, affects the strength not at all.

______________ Increasing Power Plant Efficiency. Aviation, v. 30, no. 12, Dec. 1931. p. 695-698. (figures)

Discussion on paper by F. W. Caldwell on propeller problems. Torsional flutter can be guarded against by the whirling test at Wright Field. One type of vibration capable of making a great deal of trouble in flight does not ordinarily appear even in the whirling test. It is a flexure of the blade in the plane of rotation of the propeller, attaining its greatest magnitude when the natural periods of vibration synchronize with the forced periods resulting from the variation of the engine torque and the impulses of the separate cylinders. This is likely to cause failures of the hub and breakages of the blade at the point of attachment to the hub.

Caldwell, F. W. Aspects of Airscrew Design. S.A.E. Meeting, Ohio, Sept. 1-3, 1931.
Also Aviation Engineering, v. 6, no. 1, Jan. 1932. p. 14-15. (figures)

Discusses various types of vibration. Use of the propeller-whirling test as a satisfactory means of checking flutter. The most troublesome form of vibration is that occurring in the plane of torque caused by the natural periods or forced vibration resulting from impulses of the engine cylinders.

Seewald, F. Flutter in Propeller Blades. N.A.C.A., Tech. Mem. No. 642, Oct. 1931. 15 p. (figures)
Translated from Z.F.M., v. 22, no. 12, June 29, 1931. p. 369-374.
Also D.V.L. Jahrbuch 1931, Rep. No. 219, Part II. p. 12-17.

Considers kinds of vibration possible and causes which might produce them, in an attempt to solve problem of flutter in propeller blades. Discusses combined torsional and bending vibrations. Recommends further experimental investigations to determine nature and causes of vibrations of propellers which have shown vibrations.

_______________ Practical Hints on Airscrews. Aircraft Engineering, v. 4, no. 45, Nov. 1932. p. 3.

Causes of airscrew vibration discussed. Assembling, balancing of airscrews and repairs to airscrews also discussed.

Constant, H. Aircraft Vibration. Roy. Aero. Soc.-Jl., v. 36, no. 255, March 1932. p. 205-250. (figures, table, discussion)

Physiological effects of vibration briefly considered. Large number of numerical cases exhibited graphically of the periodic forces imposed by engines and airscrews and various aerodynamic effects, and the resulting vibrations set up. Discussion brought out sufficiently the difficulties of measurement and interpretation. Paper important as a quantitative contribution to the subject.

Duncan, W. J. and Collar, A. R. The Present Position of the Investigation of Airscrew Flutter. British A.R.C., R. & M. No. 1518, Dec. 15, 1932. 44 p. (appendix, figures, tables, references)

Part I - General review of past work on airscrew flutter with brief and non-mathematical account of investigations described in Parts II and III.

Part II- Mathematical discussion of the stability of a solid cylindrical blade in an airstream.

Part III-Account of experiments on model airscrews with very flexible blades. Describes simple arrangement for visual observation of flutter of rotating blades. Experiments provide clear demonstrations of the occurrence of unstable coupled oscillations of propeller blades, and show that critical flutter speed rises greatly as the center of gravity is moved towards the leading edge.

Guglielmetti, A. Prove Dinamiche degli Aeroplani. Rivista Aeronautica, v. 8, no. 7, July 1932. p. 26-60. (figures)

Various dynamic tests for airplanes and parts are proposed and their equipment described. A method for subjecting the equipment to vibration due to the engine-propeller group is outlined. Tests are considered for reproducing the various contingencies of flight with a reproduction of the vibration effects due to external causes or those created by the engine-propeller group. Complete tests covered of the control parts, and of separate structural parts. Details of a means for testing propeller blades on an oscillating bench under centrifugal forces. Tanks and radiators can be tested by the same means.

Hohenemser, K. Beitrag zur Dynamik des elastischen Stabes mit Anwendung auf den Propeller. Z.F.M., v. 23, no. 2, Jan. 28, 1932. p. 37-43. (figures, table, references)

Theoretical discussion of the flexural overtones of stationary and rotating blades. Deflections are shown graphically for the first and second overtones. An example is worked out for an airscrew blade and numerical results tabulated for the principal mode and for the first and second overtones. It is shown that the latter may arise with engines of more than 5 cylinders.

Liebers, F. Resonance Vibrations of Aircraft Propellers. N.A.C.A., Tech. Mem. No. 657, Feb. 1932. 44 p. (figures, references)
Translated from L.F.F., v. 7, no. 3, May 16, 1930. p. 137-152.
Also D.V.L. Jahrbuch 1930, Rep. No. 182. p. 79-94.

Consideration of the various possible kinds of propeller vibrations; resonance vibrations caused by unequal impact of propeller blades being the most important. Their theoretical investigation made by separate analysis of torsional bending vibrations, followed by mathematical application of the principles explained. The calculated data is illustrated by practical examples. Conclusions.

Liebers, F. Propeller Tip Flutter. N.A.C.A., Tech. Mem. No. 683, Sept. 1932. 17 p. (figures, references)
Translated from Z.F.M., v. 23, no. 9, May 14, 1932. p. 251-259.
Also D.V.L. Jahrbuch 1932, Rep. No. 274, Part II. p. 20-28.

Report is limited to a case of tip-flutter where outside interferences force vibrations upon the propeller. Such interferences may be set up by the engine or may be the result of an unsymmetrical field of flow. Discussion based on mathematical analysis of natural frequencies of propeller blades with respect to the r.p.m. Theoretical results given. Experiments, experimental method and test results described.

Morris, J. The Two-Bladed Airscrew. Aircraft Engineering, v. 4, no. 36, Feb. 1932. p. 34. (figures, references)

Author is well-known for his mathematical investigations of torsional vibration. In this article he summarizes H. Constant's remarks on airscrew aerodynamic couples in a recent Royal Aeronautical Society lecture. Then he gives the mathematics of the theory of gyroscopic couples of two-bladed airscrews. Finally, he recalls the whirling of shafts carrying two-bladed airscrews. The article constitutes a short but complete mathematical account of the peculiarities of two-bladed airscrews.

Serragli, G. Un Sistema di Frenatura Aerodinamica. L'Aerotecnica, v. 12, no. 7-8, July-Aug. 1932. p. 1008-1023. (figures)

An aerodynamic brake for airplanes, invented by the author and tried out in Germany on a Klemm monoplane, is described. Construction problems arising in the design of the propeller to avoid dangerous vibrational effects are dealt with, and a method for mixed wood and metal construction is outlined.

Capon, R. S. The Reduction of Aircraft Noise. Engineering, v. 136, no. 3537, Oct. 27, 1933. p. 475-477; no. 3538, Nov. 3. p. 503-504. (appendix, figures, tables, references)

Discusses engine and airscrew as two chief sources of noise in aircraft.

Couch, H. H. Study of Types of Vibration Possible in Aircraft Propellers. A.C.I.C., v. 7, no. 683, Nov. 20, 1933. 20 p. Air Corps Tech. Rep. No. 3891. (figures)

Part I - A study of types of vibration possible in an aircraft propeller. A standard method for finding the natural frequencies, types of vibration and location of nodes are given. Tests conducted at Wright Field.

Part II- A vibration study of Air Corps propeller blade 32L3687 for blade angles at the 42 degree inch station of 0, 10, 20, etc. up to 80 degrees. Photographs showing the location of the nodes for each of above angle settings. Standard method described in Part I used. Conclusions and recommendations.

_______________ Making Wooden Airscrews Last Longer. Aeroplane, v. 46, no. 9, Feb. 28, 1934. p. 354.

Process developed by Schwartz airscrew works in Germany for protecting wooden airscrews. By this process, airscrew is completely enclosed within a celluloid-like casing hermetically sealed. The claim is made that the process increases torsional rigidity and so prevents flutter.

Caldwell, F. W. Aircraft-Propeller Development and Testing Summarized. S.A.E.-Jl. (Trans.), v. 35, no. 2, Aug. 1934. p. 297-310; no. 3, Sept. p. 349-358. (figures, tables, equations, discussion)

Aug. - Brief discussion of the aerodynamics of aircraft propellers and experiments carried out in the U. S. in the last few years. Included is a discussion of stress analysis and methods of measuring vibration stresses. Determination of the natural periods of vibration by tests. Measurement of vibratory stress in rotating blades by means of "extensiometers". Sept.- Propeller testing for determination of strength. For the purpose of making accelerated tests of the effect of forced vibration under severe overload, a vibrating machine is described.

Constant, H. Aircraft Vibration. British A.R.C., R. & M. No. 1637, Oct. 1934. 30 p. (appendices, figures, tables)

Summarizes progress made in researches into source and general characteristics of aircraft vibration. Describes theoretical and experimental work recently carried out at Royal Aircraft Establishment. Vibrograph tests, carried out on engines on the test-bed, on the hangar, and in aircraft in flight and on the ground.

Calculated the forces and couples due to the engine and airscrew that are effective in producing vibration, and the magnitude of their effect measured.

Couch, H. H. A Study of Propeller Vibration. Aviation, v. 33, no. 6, June 1934. p. 179-180. (figures)

Investigation into the problem of repeated failures of metal propellers, built from materials the endurance limits of which were well above the stresses computed for them under operating conditions. Since the problem was not one of simple stresses, a study was made of types of vibration possible in aircraft propellers to learn whether vibration was responsible for the failures. Description of actual experimentation - blade action under vibration. Study of 16 blade failures which occurred during operation. Causes of failure. Effect of blade angle on resonant frequencies. An Air Corps Information Circular gives standard method for obtaining the resonant vibration frequencies.

Morris, J. Some Dynamical Characteristics of Propellers. Roy. Aero. Soc.-Jl., v. 38, no. 288, Dec. 1934. p. 987-997. (figures)

General expressions given for forces and moments of inertia of blades. A simplified blade form being assumed, the solution of differential equation of bending vibration developed in series for first and third approximations. Numerical values are found for the blade form assumed. Alternatively, Rayleigh's approximate method applied and numerical results given. Torsional vibrations discussed for a simple case and the results extended to a crankshaft with many throws.

________________ Research Symphony. Aviation, v. 34, no. 6, June 1935. p. 15-18. (figures)

Brief recapitulation of some of the principal movements of the 10th Annual Engineering Research Conference of N.A.C.A. includes discussion of propeller vibration. Method of scaling down propeller vibration effects for study is shown. Discusses change in mounting and method of filtering out propeller noise.

________________ Scheduled Air Line Accident Reports. Air Commerce-Bul., v. 7, no. 4, Oct. 15, 1935. p. 92.

Cause of accident to Stimson Model A plane of Delta Air Lines, Inc. on Aug. 14, 1935 disclosed. Left out-board engine was torn from plane as result of unbalanced condition caused by breaking of propeller blade. Failure occurred as result of resonance condition due to natural periods of vibration of propeller blades, engine, and engine mount coinciding with the engine speeds and propeller pitch settings used in flight operations with this particular type and model aircraft. Corrective measures taken.

Burton, W. E. Testing Propeller Blades. Popular Aviation, v. 16, no. 4, April 1935. p. 229-230; 260-261. (figures)

An analysis of perfected methods for testing propeller vibration.

Dryden, H. L. An Experimental Attack on the Propeller Vibration Problem. Paper - Session on Power Plants and Fuels, Third Annual Meeting, Inst. of Aeronautical Sciences, Jan. 29-30, 1935.

Aim of study is a diagnosis of the causes of failures of propellers in flight. Evidence points to resonant vibrations of the propeller blade itself or of the propeller-crankshaft system as the source of alternating stresses of sufficient magnitude to produce the observed failures. Line of attack outlined: (1) develop a method for applying periodic impulses of controllable frequency and amplitude to non-rotating blades, so as to set up resonant vibrations of sufficient amplitude to cause failure, if possible; (2) develop a method for measuring the stresses set up in the vibrating blade and, if possible, obtain values at the points of failure for the stresses just preceding failure; (3) extend these methods to propeller blades in rotation. Description of model and type of equipment used for vibrating non-rotating propellers; possibility of vibrating rotating propellers by same means.

Hansen, M. and Mesmer, G. Luftschraubenschwingungen. Aircraft Engineering, v. 7, no. 73, March 1935. p. 65-69. (figures, references)
Translated from Z.F.M., v. 24, no. 11, June 6, 1933. p. 298-304. (figures, table, references)

A simple method for calculation of natural frequencies $\nu_0$ and $\nu_1$, of the bending oscillations. Simple model experiments, by which the calculated frequencies have been checked by actual measurement; good agreement.

Effect of centrifugal forces on the frequency of oscillations of a revolving airscrew are examined. The most important result was the discovery that not only the fundamental free oscillations, but also the overtones of the first order can occur within the working range of a high speed airscrew, and that the power unit is the main cause of the oscillations. With the same type of apparatus, tests were also made on a stationary aeroplane which confirm the results of calculations. Review of the fundamental principles on which the method of calculating the natural frequencies of airscrew oscillations is based.

Munk, M. M. Propeller Stresses. Aero Digest, v. 26, no. 5, May 1935. p. 22-26. (figures)

An elementary descriptive account is given of the stresses in an airscrew, particularly from vibration in resonance. Simple formulae are given with a correction factor for blade vibration. Test described whereby the propeller can be conveniently observed and the nodes of the critical vibration located. Corrections proposed.

Ramberg, W., Ballif, P. S. and West, M. J. Method for Determining Stresses in a Non-Rotating Propeller Blade Vibrating with a Natural Frequency. Bur. of Standards-Jl. of Res., v. 14, no. 2, Feb. 1935. p. 189-215. Res. Paper No. 764. (figures, tables)

Propeller failures in flight generally are fatigue fractures which point to resonant vibrations setting up excessive alternating stresses as probable cause of failure. A method is described for measuring and calculating such alternating stresses for the case of a non-rotating propeller vibrating in resonance with an alternating torque applied to its shaft. Complete picture of stress distribution in such a propeller is obtained. Stress distributions are obtained for a duralumin blade vibrating with its fundamental mode and for the same blade vibrating with its second harmonic mode (with a node near the tip). Measured stress distributions and frequencies for two modes checked by those calculated from theory of vibrating beams of variable section. The effect of restraint at the hub on frequency and on stress distribution investigated theoretically. A further check on the measurements made by examining artificially produced fatigue failures in eight non-rotating blades. Experimental and theoretical discussion.

Theodorsen, T. Vibration of Propeller and Engine Crankshaft. Paper - Session on Aerodynamics, Third Annual Meeting, Inst. of Aeronautical Sciences, Jan. 29-30, 1935.

Classification of propeller failures (shank and tip failures). The former caused by engine-crankshaft unit forming a mechanical system (propeller-engine combination) capable of torsional vibrations. Due to concentration of inertia in propeller and engine, there is only one critical response frequency in the neighborhood of 10,000-13,000 vibrations per min. for modern one and two row radial engines. In the latter case, propeller exhibits several modes of critical response. Fundamental near 2000 cycles per min., second mode at about 6,000 and the third at 10,000-12,000. Frequencies easily measured on stationary propeller; they are increased by the effect of centrifugal force. A new method developed to obtain this effect accurately by simple means, which is the use of a 1/10 size model stretched to full size along the blades. Method described. Results of experimental tests show good agreement with available results by Liebers for the fundamental, and theoretical calculations by Hohenemser for the second and third mode.

Theodorsen, T. Propeller Vibrations and the Effect of the Centrifugal Force. N.A.C.A., Tech. Note No. 516, Feb. 1935. 13 p. (figures, references)

Method devised for determining the frequencies of the various modes of a stationary propeller and the associated crankshaft. Also a method for obtaining the effect of the centrifugal force on a revolving propeller by the use of a flexible model. The various modes of vibration that a propeller is capable of performing are first described, and convenient methods of determining them explained. Mathematical instructions for applying the methods.

Van Vliet, J. D. Stresses in Propeller Blades. Popular Aviation, v. 16, no. 4, April 1935. p. 237-238;263-264. (figures)

A graphical analysis of stresses developed in airplane propeller blades during flight, the vibrations that attend the operation of the propeller and the materials employed.

Caldwell, F. W. Propeller Advances. Aeronautical Sciences-Jl., v. 3, no. 6, April 1936. p. 219.

Subject of propellers outlined to provoke discussion by other speakers. Particular reference is made to interrelation of propeller and power plant in regard to aerodynamics and resonance vibrations and to materials and stresses. Extensiometers for measurement of vibration stresses are named.

Clousing, L. A. Analyzing Propeller Vibrations. Western Flying, v. 16, no. 5, May 1936. p. 11-12, 26, 28, 45. (figures)

Analysis concerning the study of the Materiel Division of the Army Air Corps. Kinds of vibrations producing propeller failure; the manner in which propellers on airplanes are set into vibration; the types of breaks caused by the various types of vibrations, and the method by which a propeller may be designed to be free from any vibrations.

Couch, H. H. Propeller-Crankshaft Vibration Problems. A.C.I.C., v. 8, no. 703, April 15, 1936. 12 p. Air Corps Tech. Rep. No. 4163. (figures)
Also Mechanical Engineering, v. 58, no. 4, April 1936. p. 215-221.

Part I - Devoted to a study of types of vibration possible in aircraft propellers. Description and photographs of typical failures. Types of crankshaft vibration discussed with reference to their effect on propeller hubs and blades. Object is to determine cause of propeller failures in Air Corps. Actual tests.

Part II- Includes a description of several types of pick-ups to obtain vibrations under operating conditions. Several methods of eliminating severe crankshaft and propeller vibrations proposed.

Lampton, G. T. Testing of Controllable-Pitch Propellers. A.S.M.E.-Trans., v. 58, AER 58-3, 1936. p. 263-266. (figures, table)

Test methods and equipment successfully used both in the development and in the testing of the Lycoming-Smith propeller. Vibration tests, conducted in accordance with the U. S. Army Air Corps technique, form the largest part of the test work. The company and several governmental agencies, notably the Air Corps, are now working on instrumentation and technique for the detection of resonance under actual operating and flight conditions.

Liebers, F. Analysis of the Three Lowest Bending Frequencies of a Rotating Propeller. N.A.C.A., Tech. Mem. No. 783, Jan. 1936. 16 p. (appendix, figures, references) Translated from L.F.F., v. 12, no. 5, Aug. 31, 1935. p. 155-160. (D.V.L. Rep. No. 35/11)

Available literature on rotating propeller oscillations reveals its lack of uniformity in interpretation, particularly as concerns the data on the overtone frequency with respect to the centrifugal forces. Present report is survey of existing data for computing the bending frequency and a check on the dependability of the calculating methods.

Lürenbaum, K. Vibration of Crankshaft-Propeller Systems. S.A.E.-Jl. (Trans.), v. 39, no. 5, Nov. 1936. p. 469-479. (figures, equations, discussion)
Also Automotive Industries, v. 74, no. 26, June 27, 1936. p. 914-916, 917.
L.F.F., v. 13, no. 10, Oct. 12, 1936. p. 346-356.

Discrepancies between torque-stand and flight measurements of torsional vibration on the same engine may explain propeller fractures due to flexural vibration. Recent fatigue fractures of crankshafts, differing from those due to torsional vibrations must be attributed to longitudinal vibration. Degrees of freedom are discussed with a graphical summary of vibration frequencies. Vibration forms, sources, stresses and resonance are subjected to mathematical analysis. Three effective measures against vibration given. It is proposed to separate the crankshaft and propeller through the interposition of a flexible spring connection to obtain a crankshaft-propeller system that would be vibration-free to a large degree within the operating-speed range. Such construction would permit decreased crankshaft dimensions and weight.

Riz, P. Determination of Natural Frequency of Airscrew Blade Oscillations. Central Aero-Hydrodynamical Inst., Moscow, Rep. No. 281, 1936. 20 p. (figures, tables, references) (In Russian with English abstract)

Approximate solution given (with several simplifying suggestions) of the problem of the natural oscillations of an airscrew blade according to the Galerkin method. Formulae given for the determination of frequency of basic tone and first overtone applicable to blades of any form with known laws of variation of the areas and moments of inertia of the section along the blade. Effect of centrifugal forces on frequency of flexural oscillations investigated. Frequency of torsional oscillations for a particular aerofoil suitable for airscrew design roughly determined.

Watts, H. C. Airscrew Development. Roy. Aero. Soc.-Jl., v. 40, no. 307, July 1936. p. 483-523. (appendices, figures, tables, references, discussion)

Discussion in general of airscrew development. Part II deals with materials (wood, aluminum alloy, magnesium, hollow steel and micarta) in use for airscrews; various advantages and properties. Relationship of these materials to fatigue, vibrations, torsional rigidity, dynamic balancing and flutter.

Wheatley, J. B. A Study of Autogiro Rotor-Blade Oscillations in the Plane of the Rotor Disc. N.A.C.A., Tech. Note No. 581, Sept. 1936. 14 p. (appendix, figures, tables, equations, references)

Analysis of the factors governing the oscillation of an autogiro rotor-blade in the plane of the rotor disc showed that the contribution of air forces to the resultant motion was small and that the oscillation is essentially a direct effect of the rotor-blade flapping motion. Comparison of calculated oscillations with those measured in flight on three different rotors disclosed that the calculations agreed satisfactorily with experiments. Calculated air forces on rotor-blade appear to be larger than experimental ones, but this discrepancy can be attributed to the deficiencies in the strip analysis.

______________ The One Blade Propeller. Aeroplane, v. 42, no. 1345, March 3, 1937. p. 253. (figures)

A propeller is described having only one blade and balanced by a counter-weight on the opposite side of the hub equal to the weight of the blade. U.S. invention claimed to increase airplane speed by 25 to 30% and the rate of climb by 33 1/3%, and to eliminate vibrations. A few details given.

______________ Offset Propeller Raises Performance. Aero Digest, v. 31, no. 2, Aug. 1937. p. 58. (figures)

Flight tests of the Maynard-DiCesar propellers have indicated increased cruising speeds, reduced vibrations, lower engine temperatures and a 10% jump in airspeed and climb. P. DiCesar, designer, states that the practice of offsetting the blades at the hub gives a decided arc which tends to bring the point of propeller fatigue 4" nearer the hub. The arc blades, he claims, incur a larger airstream by a larger bite of air, this airstream leaving the blades at a sharp bias and being directed under the plane.

Caldwell, F. W. The Vibration Problem in Propeller Designing. S.A.E.-Jl. (Trans.), v. 41, no. 2, Aug. 1937. p. 372-380. (figures)

Paper presents an effort on the part of the propeller designer to look at some phases of the vibration problem as it affects him. Brief description of some of the work being done in vibration. The subject is treated from the aspect of experimentation and the physical phenomena without any effort to introduce the mathematical phase of the subject. Examples are given of the measurements of the vibratory stress in propeller blades by a new method introduced during the last year.

Carter, B. C. Airscrew Blade Vibration. Paper - Roy. Aero. Soc., March 11, 1937.

Past works on propeller vibrations suffer from a number of inaccuracies both as to the mathematical treatment as well as in the experimental methods adopted. This paper attempts to fill these gaps.

De Forest, A. V. Measurement of Propeller Stresses in Flight. Aeronautical Sciences-Jl., v. 4, no. 6, April 1937. p. 227- 232. (figures, bibliography)

Practical solution of the problem of measuring aircraft propeller stresses in flight. For study of the airplane propeller equipment must be designed to result in giving adequate strength to all parts with a minimum of parasitic weight in order not to decrease the aerodynamic efficiency of the propeller blade. Various devices were used and failed. Ultimately, a pick-up, which fulfilled the desired conditions to a degree which permitted a practical and accurate continuous recording of propeller stresses in flight, at any selected points of the hub and blades, was evolved. Suitable directional accelerometer units and torsional vibration units have been evolved at M.I.T. It is to be expected that a combination of these instruments with a dynamic strain measurement of all important parts of propeller and engine will lead to a much better understanding of the origin of propeller stresses than has heretofore been possible.

# AIRCRAFT ENGINE VIBRATION

Simmons, L.F.G. Investigation of the Fracture of Exhaust Springs. British A.R.C., R. & M. No. 241, March 1916. p. 585-592. (appendix, figure).

Investigation of the cause of fracture of exhaust springs. Various conceivable causes examined. Failure attributed to fatigue, due to excessive oscillations set up through synchronisation of vibrations due to the motor with those of the spring. Period of vibration determined by experiment and confirmed by calculation. Remedy suggested. Appendix is a mathematical investigation into vibrations of a spiral spring under an initial compressive load, with a view to the improvement of the design for a particular engine.

Morris, J. The Bending, Vibrating, and Whirling of Loaded Shafts. British A.R.C., R. & M. No. 551, Oct. 1918. 39 p. (appendices)

Simple method for dealing with the whirling of a shaft, running in any number of bearings and having any number of concentrated loads, of which the inertia is taken into account. New method of attacking the design problems of avoiding critical speeds for all angular velocities of crankshaft required in flight. General formulae for practical cases. These, with tables giving various coefficients connected with shafts or beams, enable one to find immediately an equation for determining required critical angular velocity, or periods of vibration, etc.

Blondel, A. Vibration et Résonance des Arbres Porte-Hélice. Inst. de France, Acad. des Sciences, Comptes Rendus, v. 178, April 22, 1924. p. 1406-1411.

Theoretical treatment and development of equations for the case where there is an appreciable length of shafting between the engine and the propeller. Application to marine engines and airship engines.

Allen, J.W. Generator Problems Due to Crankshaft Vibration. Mechanical Engineering, v. 47, no. 10, Oct. 1925. p. 793-794. (figures)

Discussion of the requirements for a generator for the Liberty-12 engine. Preparations are under way actually to measure the generator-drive deflection by locating a wheatstone-bridge network at points where the amount of deflection is desired. Oscillograph records will be taken under conditions of no deflection. Should these tests come up to expectations, the actual deflections and stresses in the generator drive will be better understood and generator couplings will be designed accordingly.

Gregg, D. Gear-Driven Plane Supercharger Passes Dayton Air Tests. Automotive Industries, v. 53, no. 22, Nov. 26, 1925. p. 906-908. (figures)

The Air Service Engineering Division finds early failure due to crankshaft torsional vibration. The use of a larger impeller shaft and flexible coupling solves the problem.

Carter, B. C. Torsional Vibration in Engines. Effects of Fitting a Damper, a Flywheel, or a Crankshaft-Driven Supercharger. British A.R.C., R. & M. No. 1053, Feb. 1926. 37 p. (figures)

Theoretical analysis to determine the minimum moment of inertia needed for a vibration damper to be effective. Analysis is given of the functioning of the viscous friction Lanchester damper. Deductions are made as regards the operation with solid friction. Formulae are evolved giving the forced vibration amplitude for the case of an engine fitted with an elastically connected viscous-friction damper. In an appendix, the question is investigated theoretically whether a lighter damper can be made to suffice, by adopting a drive of suitable elasticity, and giving the damper-coefficient its corresponding optimum value.

Carter, B. C. and Swan, A. Torsional Vibration. Automobile Engineer, v. 16, no. 213, March 1926. p. 86-88. (figure)

Notes in connection with crankshaft-airscrew systems. Enumeration of the general conclusions reached regarding multi-crank engines, and outline of a simple method of determining the frequency of natural vibration in particular cases.

Moullin, E. B. On the Equivalence Between the Dynamical System of a Multi-Crank Flywheel System and a Certain Electrical Circuit, with some Suggestions for Measuring Critical Speeds and Shaft Stresses by Analogy. British A.R.C., R. & M. No. 1045, April 1926. 9 p. (figures)

Because of breakages of crankshaft of large aeroplane engines, and because of the relative lightness of these engines, existing methods of analysis have to be modified to find and avoid critical speeds, and for calculation of stresses. A simple method given for avoiding calculation of the critical frequency. Extension proposed to include case of variable inertia, and the case of a couple acting on each crank. Suggestions added for suitable sizes of the moments of inertia of the system.

Calderwood, J. An Investigation of Torsional Vibration, with Particular Reference to Aircraft Engines. Junior Inst. of Engineers-Jl. and Rec. of Trans., v. 37, Part 12, Sept. 1927. p. 607-622. (appendix, figures, references, discussion)

Observations on torsional vibration. Appendix contains formulae derived for calculation of natural frequency of vibration of various arrangements of shafting such as occur in airplane and airship engines.

Carter, B. C. Dynamic Forces in Aircraft Engines. Roy. Aero. Soc.-Jl., v. 31, no. 196, April 1927. p. 278-328. (appendix, figures, references, discussion)

Discussion of natural torsional vibration and its application to single-throw radial engine. Calculation of main synchronous speed. Effects of driving damper or supercharger from tail end of crankshaft. Effects of big end clearance in single-throw radial engines. Torsional vibration in multi-crank engines. Frequency equations for various airscrew-crankshaft systems.

McLaughlin, G. F. Ford's Latest Monoplane. Aero Digest, v. 10, no. 2, Feb. 1927. p. 95.

A full description of Ford's two-cylinder, air-cooled, light monoplane of the low-wing type. The two cylinders are horizontally opposed, offset because of the double-throw crankshaft. This type of cylinder arrangement is easy to balance, and vibration presents no problem.

Morris, J. Dynamical Forces in Aircraft Engines. Some Observations on Major Carter's Paper. Roy. Aero. Soc.-Jl., v. 31, no. 198, June 1927. p. 577-585.

Mathematical discussion--should the running speed be above or below the critical speed, and if so, by how much? Discussion in relation to Major Carter's paper on torsional vibration, v. 31, no. 196, p. 278-328.

______________ The A.B.C. "Hornet" Engine. Flight, v. 20, no. 33, Aug. 16, 1928. p. 702-705. (figures)

A.B.C. Motors, Ltd. has developed an air-cooled, "flat twin", 4-cylinder engine, the Hornet, 75 B.H.P. at 1875 r.p.m. When Hornet is running on test bench, one can feel no vibration at all, and a very small spring washer, left on the framework of the test bench, remained there for many hours of running. Not only has this washer not been shaken off, but it does not appear to move at all. This is not a very scientific proof of the smoothness of the engine, but does provide a rough and ready demonstration of entire absence of vibration. Actual test in aeroplane to be made in a "Widgeon" light plane.

Constant, H. On the Stiffness of Crankshafts. British A.R.C., R. & M. No. 1201, Oct. 1928. 16 p. (appendix, tables, figures)

A number of crankshafts were submitted to static torsional tests out of bearings, and from the results, a rational formula was devised for stiffness of a "normal" crankshaft under these conditions. The effect of "abnormalities" was ascertained, and a method was reached for making a close estimate of the stiffness of crankshafts of widely varying design. Application of formula for determination of torsional resonance speeds, briefly considered.

Morris, J. Shaft Speeds. Automobile Engineer, v. 19, no. 242, June 1928. p. 217-219. (figures)

Analysis of best running conditions for aircraft-engine crankshafts. Avoiding running speed which may approximate too closely to resonant speed. Question of whether running speed should be above or below critical speed and if so, by what amount. Determining lightest shaft able to withstand stresses involved in running.

—————— Zur Frage der Kurvenbahmotoren. Autom. Tech. Zeit., v. 32, no. 22, Aug. 10, 1929. p. 479.

The analysis of this engine, which instead of a crankshaft employs a special cam contour, showed a large variation in torque which may be the cause of the heavy vibration observed when mounted in an aeroplane.

Beck, W. Progress in Germany. Aircraft Engineering, v. 1, no. 3, May 1929. p. 81-82.

Description of the new Junkers engine. Trial flight with Junkers engine, Mark 01, was carried out without any casing on the front of it and lasted 15 minutes. Demonstrated the fact that, when mounted in an aeroplane, its performance was faultless, and that the two Junkers oscillation dampers, with which it was provided, rendered it quite free from vibration at all speeds.

Kemm, W. and Stieglitz, A. Schwingungsuntersuchungen an der Maschinenanlage des Luftschiffes "Graf Zeppelin". Z.F.M., v. 20, no. 18, Sept. 28, 1929. p. 465-474. (figures)
<ins>Also</ins> D.V.L. Jahrbuch 1930, Rep. No. 145. p. 255-264.

Experimental tests and theoretical analysis used to determine the cause and remedy for the crankshafts. Conclusion arrived at was that they had been subjected to some unusual stress prior to their breaking. Source of trouble was torsional vibration of the crankshaft. Remedy was to alter the vibration periods by increasing the elasticity of the clutch spring and lightening the counterweights. Incorporated vibration dampener.

Ogawa, S. On the Torsional Vibrations of Aero Engines. Soc. Mech. Engrs.(Japan)-Jl., v. 32, no. 141, Jan. 1929. p. 1-26. (In English)

Problem of critical speeds of airplane engine is solved in four steps. Masses of pistons, connecting rods, and crank are reduced, and equations of oscillation, modified for crank, are solved. When critical speed is considered as variable with crank angles, equivalent masses are obtained and equations of oscillation at every interval are solved. When periodic external forces are taken into account, equivalent masses are obtained and equations of forced oscillation are solved. Experiments on Hispano 300 hp. engine.

Shoemaker, J. M. Reliable Power Plants for the Airship. Aviation, v. 27, no. 24, Dec. 14, 1929. p. 1158-1162. (figures)

Interesting facts regarding requirements in the operation and explanation of the four out of five failures of the Graf Zeppelin engines. The spring coupling, in its original form, caused resonance between the primary and secondary torsional vibrations from 1450 to 1550 r.p.m. When the coupling was stiffened by increasing the spring diameters and eliminating the play, the range of resonance dropped to 1300-1400 r.p.m. In investigating power plant failures, Dr. Kamm employed a modified Geiger torsiograph in determination of torsional vibration resonance ranges. The new flexible coupling, as at present installed in the Graf Zeppelin, was also tested. This coupling moved the range of resonance down to around 1200 r.p.m.

Stieglitz, A. Drehschwingungen in Reihenmotoren. L.F.F., v. 4, no. 5, July 24, 1929. p. 133-158. (figures, equations, references)
Also D.V.L. Jahrbuch 1929, Rep. No. 140. p. 449-474.

Theory of torsional resonance as the cause of engine failure discussed. Test results covering the design of standard aero engines give practical scope to the theoretical results. Vector diagrams used. Also indicator diagrams to determine pressure forces. Inertia forces calculated. The natural frequency of crankshaft determined by experiment and compared with the value calculated. Examples of critical speeds worked out for 6 and 12 cylinder engines. The theory of linear damping is worked out and formulae developed. Attempt is made to extend the results to solid friction damping. Method for rapid practical calculations in the case of similar types of engines; modifications required for new types.

Thoma, H. Untersuchungen an der Maschinanlage des Luftschiffes "Graf Zeppelin". Z.V.D.I., v. 73, no. 39, Sept. 28, 1929. p. 1383-1388. (figures, references)

During flight to America in May 1929, four of the five engines failed by fracture of the crankshaft through resonant vibrations brought into the working range by an alteration in the tension of the spring coupling between the engine and the airscrew. The cause of the failure of the vibration dampers considered. Method of avoiding the resonant period discussed. A method is described for measuring crankshaft vibrations.

Wedemeyer, E.A. Kurbelwellenschwingungen. Z.F.M., v. 26, no. 6, March 28, 1929. p. 145-149. (figures, table, reference)

Method of calculating critical periods developed which is more rapid and certain than existing methods. A detailed calculation of a six-throw crankshaft exhibits a concise solution of the differential equation by means of a series as first proposed by Brauchitsch.

______________ L'Equipement du Groupe Moteur. L'Aeronautique, v. 12, no. 128, Jan. 1930. p. 27-32. (figures)

Included is a description of a series of vibration tests to which the tubing of an airplane has been submitted. Results and recommendations. Experiments with couplings including one on vibration under pressure.

______________ Apparato Comper per Assorbire le Vibrazioni. Rivista Aeronautica, v. 6, no. 3, March 1930. p. 560-561. (figure)

A small, light and economical instrument which may be used for every type of engine and consists of a steel cylinder inside of which is a cylindrical rubber block. The compression is obtained by a threaded rod passing through the center of the rubber block to one end of which is a nut which tightens an end plate next to the end of the rubber cylinder. The end of the rod, opposite the threaded end, provides a means of coupling to the objective.

______________ The Short "Valetta". Flight, v. 22, no. 30, July 25, 1930. p. 825-830. (figures)
Also N.A.C.A., Aircraft Circular, No. 125, Aug. 1930. 7 p.

Description of the "Valetta", an all-metal high-wing twin-float monoplane, includes constructional details of the power plant which consists of three of the new Jupiter series XI-F engines. In order to reduce vibration transmitted from engines to aircraft structure, novel form of shock-absorbing or vibration-damper arrangement evolved. This consists in interposing between engine plated and supporting structure a series of rubber pads. The engines are "floating on rubber" and reduction of vibration in cabin is considerable.

______________ Schwingungsdämpfung. Z.V.D.I., v. 74, no. 32, Aug. 9, 1930. p. 1122. (figure)

Junkers vibration damper has become standard for other engines including the B.M.W. 4. It weighs approximately 15 lbs. and reduces deflection of crankshaft to half. Oil is the damping medium and in the new arrangement the lubricating oil flows freely through damper, which it lubricates and cools.

______________ Dawn Motor Performs Unusual Vibratory Test. Popular Aviation, v. 7, no. 3, Oct. 1930. p. 30. (figure)

Miss Bobbie Trout, twice holder of the world's altitude record for women, has devised an unusual "egg test" for detecting vibration in her Dawn motor. Although the spark plug wires from one cylinder are disconnected, the egg does not jiggle, due to the reciprocating action of the new motor. The spoon, which holds the egg, is clamped to the motor.

______________ Insulating the Engine Mountings. Aeroplane, v. 39, no. 15, Oct. 8, 1930. p. 829. (figure)

Description of a vibration damping device, "Silentbloc", on which engine of the Gipsy III is mounted. This mounting has steel inner sleeve surrounded by a rubber bush which is compressed inside the outer case, and makes possible the use of a much higher loading per sq. in. than can be used in the ordinary way. The inner sleeve may be moved through 90 degrees in either direction relative to the outer case, so that the device is suited to oscillating movement.

Carter, B.C. The Effects of Viscous and Solid Friction in Airscrew Drives in Damping Torsional Vibration. Third Inter. Cong. for Appl. Mech.-Proc., v. 3, Aug. 1930. p. 198a-198e. (figures, references)

Torsiograph investigations made with a single throw radial engine fitted with a spring hub show that the damping inherent in the vibrating system is quite small when a hub damper is not fitted. The combination of spring hub and damper constitutes a positive means of introducing damping into the system in any required degree. The mathematical investigation in this report was made in order to form a basis for design. Several systems shown, formulae derived which give the amplitude of motion for known damping factors in the engine and dampers.

Carter, B. C. and Muir, N. S. Torsional Vibration of Crankshafts. Beardmore "Tornado" Airship Engine Investigations. British A.R.C., R. & M. No. 1303, July 1930. 56 p. (appendices, figures)

From calculataions made during early stages of development of the "Tornado" engine for use in H.M. Airship R101, it was inferred that serious torsional vibration would be experienced in the region of 950 r.p.m. unless modifications were made to the design. Crankshaft torsional stiffness test made to obtain more exact data for revised calculations. Stiffer crankshafts put in and torsiograph tests were carried out on first engine to be run with an airscrew fitted. Results confirmed predictions made from the theory, and failures due to torsional resonance during tests. Information relating to resonance calculations given in Appendix I.

Chilton, R. Airplane-Engine Development and Operating Reliability. S.A.E.-Jl.(Trans.), v. 26, no. 6, June 1930. p. 771-781. (figure)

Discussion of failures in engines from fatigue originating from small local defects in the material or from resonant vibrations which carry the stresses beyond the safe fatigue-limit of the material. Emphasis placed on the importance of determining that no natural resonant vibration periods of the parts are encountered within the operating speed range. Description of means of measuring torsional vibrations.

Gasterstädt, - Development of the Junkers-Diesel Aircraft Engine. N.A.C.A., Tech. Mem. No. 565, May 1930. 20 p. (figures)
Translated from Autom. Tech. Zeit., v. 33, no. 1, Jan. 10, 1930. p. 2-5; no. 2, Jan. 20. p. 41-46.

Foremost among the difficulties encountered in the development of the Diesel aircraft engine is the requirement of high speed and light weight. Account of how this difficulty has been met. Examples of early Junkers design; history and performance of 650 h.p., two-cycle engine; fuel injection and scavenging systems; vibration tests; details of present design.

Geiger, J. Vibrations de Torsion des Vilebrequins et Vibrations de Flexion des Pales d'Hélices. L'Aeronautique, v. 12, no. 138, Nov. 1930. p. 403-406. (figures)

Causes and effects of crankshaft vibrations and methods of their investigation with the Geiger torsiograph. Opation of the torsiograph is illustrated.

Kamm, W. Der Argus, Flugmotor As 8. Z.V.D.I., v. 74, no. 41, Oct. 11, 1930. p. 1409-1412. (figures)
Also Deutsche Motor-Zeit., v.7, no. 8, Aug. 1930. p. 387.

Design and specifications of most successful engine in 1930. European circuit contest. Inverted 4-cylinder in-line air-cooled engine of 30 h.p. continuous output of 120 by 130 mm. bore and stroke, weighing 112 kg. Performance and torsional vibration characteristics.

Küssner, H.G. Rechnerische und Experimentelle Untersuchung von Schwingungen an Flugzeugen. Third Inter. Cong. for Appl. Mech.-Proc., v. 3, 1930. p. 275-278. (figures)

Report deals with the exciting forces due to the engine vibrations, aerodynamic stress of the propeller and airfoils, airfoil oscillations, etc. Description of the method used to determine the vibrations of individual parts of an aircraft under exciting action of the engine.

Lürenbaum, K. Die Schwingungen in Luftfahtzeug-Treibwerkanlagen. L.F.F., v. 6, no. 4, Feb. 14, 1930. p. 97-102. (figures, discussion--p. 109-110)
Also D.V.L. Jahrbuch 1930, Rep. No. 158. p. 275-380.

Oscillations and dynamic stresses which are a source of hazard to an airplane power plant are studied, but without aid of numerical data, and with special reference to torsional vibrations, which are probably the main cause of failures. Means of reducing the hazard of torsional vibrations are studied.

Matthaes, K. Kurbelwellenbrüche und Werkstoffragen. L.F.F., v. 8, no. 4, July 28, 1930. p. 91-120. (figures, tables, references)
Also D.V.L. Jahrbuch 1930, Rep. No. 196. p. 443-472.

Investigations to discover the causes of broken crankshafts with 6-cylinder-in-line engines. In the case of a majority of crankshafts, the position and shape of the fracture determined, and conclusions drawn as to stresses to which the crankshafts were subjected. Various properties investigated, including continuous-bending strength and resistance to torsional oscillations. Means for avoiding fractures, the question of fractures of crankshafts is one of construction.

Muir, N. S. and Terry, A. A Harmonic Analysis of the Torque Curves of a Single Cylinder Electric Ignition Engine When Throttled to Various Mean Indicated Pressures, with an Appendix on the Estimation of Forcing Torques in Multi-Cylinder Engines. British A.R.C., R. & M. No. 1305, March 1930. 14 p. (appendix, figures, tables)

This report presents an analysis of torque curves corresponding to conditions under which various orders of torsional vibration occur. Analysis is of a single cylinder of a "Liberty" electric ignition aircraft engine, based upon an indicator diagram taken at full throttle. Values of harmonic torque coefficients given in tables and plotted in diagrams. Coefficients due to inertia resistance of the connecting rods also plotted.

Prescott, F. L. Vibration Characteristics of Aircraft Engine Crankshafts. A.S.M.E.-Trans., v. 52, AER 52-19, 1930. p. 139-152. (figures, table, equations, references, discussion)

Vibration characteristics of aircraft-engine crankshafts are discussed. Presents an analysis of test records of various engines in which a torsiometer was used, and also a practical exposition of the torsiometer. Method of calculating the frequency of torsional vibration is described and applied to a Liberty-12 engine.

Stieglitz, A. Neuere Ergebnisse auf dem Gebiet der Kurbelwellenschwingungen. L.F.F., v. 6, no. 4, Feb. 14, 1930. p. 103-110. (figures, references, discussion)
Also D.V.L. Jahrbuch 1930, Rep. No. 159. p. 281-288.

Failures of shafts due to superposition of torsional oscillation loads on the steady load. Elastic energy relations considered, and exciting and damping forces discussed. The specific work is plotted graphically and indicates the critical points. Influence of order of firing; the most favorable arrangement for a 6 cylinder engine. Effectiveness of a damping arrangement and the most favorable adjustment determined. Resonance curves prepared from engines with and without dampers. Brief account of methods of measurement.

Warner, E. P. Engines Before the S.A.E. Aviation, v. 28, no. 9, March 1, 1930. p. 439-442. (figure)

Reference is made to the report of Mr. Chilton made at the S.A.E. session at St. Louis which was devoted to power plant problems. Discussion of failures in flight as caused by effects of resonant vibration. A number of examples given of their alarming magnitude and possible means of coping with them. Crankshaft failure on the Graf Zeppelin cited as an example.

_______________ L'Ammortizzazione delle Vibrazioni nei Motori d'Aviazione. Rivista Aeronautica, v. 7, no. 4, April 1931. p. 148-154. (figure)

Report from the Junkers Laboratory on the possibilities of avoiding breakages of crankshafts of aircraft engines due to vibrations.

_______________ The Problem of Engine Vibration and Passenger Comfort. Aviation, v. 30, no. 5, May 1931. p. 314-315. (figure)

Suggestions of methods for the prevention of vibration by incorporating cushioning pads between the engine and the supporting structure.

_______________ A Spring Hub for Aero-Engines. Aircraft Engineering, v. 3, no. 33, Nov. 1931. p. 279-280. (figures, references)

Description of a flexible airscrew drive damping out torque variation which also forms a transmission dynamometer. Description of a mechanical method of overcoming the dangers of torsional vibration involving major and minor critical periods.

Capetti, A. Sul Calcolo dei Periodi di Oscillazione Torsionale Libera degli Alberi. L'Aerotecnica, v. 11, no. 2, Feb. 1931. p. 157-166. (figures, equations, references)

Methods of determining the natural frequencies with particular regard to graphical methods developed according to Kutzbach.

Carter, B.C. On the Effects of Viscous and Solid Friction in Airscrew Drives in Damping Torsional Vibration. British A.R.C., R. & M. No. 1557, Feb. 1931. 25 p. (figure)

Report contains three main sections: (1) Mathematical analysis of forced torsional vibration for a simple engine system incorporating a spring hub fitted with a viscous friction damper. (2) Mathematical analysis of a forced torsional vibration for a simple engine system incorporating a spring hub fitted with a solid friction damper, the crankshaft being treated as rigid. (3) Applications of results to some typical problems. Special application of equations derived is given whereby the action of a continuously slipping clutch in damping torsional vibrations is examined.

Mahoux, M. À propos des Ruptures dues aux Vibration. Soc. Générale de l'Aeronautique, 1931. p. 29-34.

Stresses imposed on a shaft by torsional oscillation exhibited graphically on large-scale polar diagram. Two micro-photographs of portions of a fractured shaft reproduced with diagrams showing the position of fracture and small portions of fractured surface photographed. Microphotographs of strained materials are added for the information of constructors.

Thalau, K. Aufgaben der Luftfahrzeug-Statik. Z.F.M., v. 22, no. 8, April 28, 1931. p. 229-241. (figures, tables, references, bibliography)
Also D.V.L. Jahrbuch 1931, Rep. No. 217. p. 67-79.

Brief survey of various types of monoplane and biplane construction, and of internal construction of wings. Methods of static tests discussed. Properties of steel and timber girders compared. Photographs of typical failures given. Stresses imposed by engine may be investigated by engine tests in the aeroplane which is suspended by rubber stays and is free to vibrate. Photograph shows fatigue fractures at four points of the welded tubular engine mounting tested this way. Summary of further investigations.

Wittman, K.O. Vibrations Damped by Fluid Friction. Product Engineering, v.2, no. 2, Feb. 1931. p. 74. (figures)

Fluid friction, rather than mechanical friction, is utilized to produce damping effect tending to eliminate torsional vibrations of crankshafts of some Junkers aircraft engines. One reason advanced is that fluid friction is more readily controllable and cannot bring about seizing in any event; use of lubricating oil; effect of damper in reducing torsional vibrations at various engine speeds.

Zoja, R. Sul Calcolo delle Molle per Valvole dei Motori d'Aviazione. L'Aerotecnica, v. 11, no. 2, Feb. 1931. p. 183-195. (tables, references)

After having verified, with suitable experiments, the results obtained by other investigators on the matter, and having shown the impossibility of the Simmon hypothesis, the author states that, at the present state of our knowledge about spring vibrations, no exact indication for the spring calculation is obtainable from it. Moreover, it is not possible to foresee vibrations or to eliminate or attenuate them except by using absorbers, which, on the other hand, present various drawbacks and are not always applicable.

__________ Vibration-Proof Tube Coupling. Aviation, v. 31, no. 1, Jan. 1932. p. 43. (figure)

The Dole Valve Co., Chicago, announced a new line of couplings and fittings for use with tubing of all materials, from 1/8" to 1/2" in diameter. Special feature of fittings is a vibration-proof type of compression coupling, which may be applied directly to tube end without machinery or soldering. Couplings are reconnectable without reduction in efficiency. Tests indicated they cannot be separated accidentally by vibration.

__________ Engine Mount of the Pilgrim. Aviation, v. 31, no. 2, Feb. 1932. p. 97-98. (figures)

Includes an article on engine mount of the Pilgrim 100-A transport plane. To damp out unpleasant vibrational effects from the engine, the motor mount incorporates rubber cushioning both between engine and mounting ring, and also between mount and fuselage proper.

__________ Tri-Motor Vibrations Curbed. Western Flying, v. 12, no. 1, July 1932. p. 34.

Brief description of a means of eliminating the recurrent periods of vibrations in tri-motor planes.

__________ A New, Light-Aeroplane Engine. Aircraft Engineering, v. 4, no. 42, Aug. 1932. p. 210-212. (figures)

D. Napier and Son developed a six-cylinder-in-line air-cooled engine. This has the advantage over other types of even torque and complete balance of secondary forces and couples, as well as of the primary and rotating forces and couples, which ensure smoothness of running and freedom from vibration. Any liability to torsional vibration, owing to the longer crankshaft, has been overcome by making it adequately stiff and providing seven bearings.

Carter, B.C., Muir, N.S. and Constant, H. Torsiograph Investigations on a Radial Engine With and Without a Spring Hub, With Some Reference to Damping. British A.R.C., R. & M. No. 1562, July 26, 1932. 14 p. (figures, tables, equations, references)

Spring hubs used in these investigations were made as an outcome of previous torsional vibration research. Torsiograph tests were made to examine the effects of torque fluctuation in airscrew drive of a fitting spring hub; also to determine the amount of damping present in the engine airscrew system. Torsiograph tests were made at the Royal Aircraft Establishment on a nine cylinder ungeared radial engine with a standard hub fitted and two spring hubs. Amplitudes of crank oscillation were determined from the analysis. Included are results of torsiograph tests made by the Bristol Aeroplane Co. on a third spring hub having a damper incorporated.

Constant, H. Aircraft Vibration. Roy. Aero. Soc.-Jl., v. 36, no. 255, March 1932. p. 205-250. (figures, table, discussion)

Description of the Cambridge vibrograph, with example of diagrams, and brief discussion of the principles of analyzing them. Physiological effects of vibration briefly considered. Large number of numerical cases exhibited graphically, of the periodic forces imposed by engines and airscrews and various aerodynamic effects, and the resulting vibrations set up. Discussion brought out sufficiently the difficulties of measurement and interpretation. Paper important as a quantitative contribution to the subject.

Constant, H. Torque Reaction and Vibration. Aircraft Engineering, v. 4, no. 40, June 1932. p. 146-149. (figures, tables, references)

Consideration given to the effect on a structure of a complex fluctuating impulse by analyzing the impulse into its component harmonics and studying the effect of each harmonic separately. At first sight, most multi-cylinder torque curves have a roughly sinusoidal appearance, but a Fourier analysis always shows the presence of a large number of harmonics. It is shown that usually only one or two of the many harmonics have any appreciable effect in producing vibration in the attached structure. Summary and analysis of results given.

Everling, E. Kurbelwellenbrüche im Luftverkehr. Autom. Tech. Zeit., v. 35, no. 1, Jan. 10, 1932. p. 22-23.

The D.V.L. has collected specimens of crankshaft fractures which have taken place during recent years in 6 cylinder engines. Fractures generally occur near the airscrew end and are spiral. They are due to resonance, which is effectively eliminated by a suitable damper.

Gorfinkel, A. Intérêt Practique de l'Etude des Vibrations de Torsion dans les Moteurs Actuels. Science Aérienne, v. 1, no. 2, Sept.-Oct. 1932. p. 122-138. (figures, tables, references, discussion)
Also Génie Civil, v. 101, no. 15, Oct. 1932. p. 355-358; no. 16, Oct. 15. p. 377-380.

A semi-empirical formula for the direct calculation of critical speeds of in-line, V, W, and radial aircraft engines developed. In applying the formula, the author demonstrates the advantages of placing the auxiliary drive and the supercharger near the propeller instead of at the opposite end of the crankshaft. A study is made of the amplitude of vibrations experienced and the effect on it of firing order and of the angles between the cylinder rows in the V and W type engines.

Lürenbaum, K. Torsional Vibration of Aircraft Engines. N.A.C.A., Tech. Mem. No. 672, May 1932. 16 p. (figures, table, references)
Translated from Z.F.M., v. 23, no. 4, Feb. 29, 1932. p. 105-113.
Also D.V.L. Jahrbuch 1932, Rep. No. 268, part IV, p. 13-21.

General outline of the methods used, the theoretical and mechanical means available in the investigation of torsional vibrations to determine the reliability of aircraft engines. Illustrated by examples. Description of the D.V.L. torsiograph and the D.V.L. recorder. Investigations of vibrations of a simple distance drive by means of the two devices is given as an example. Results and discussions of vibration tests. Vibration damping is referred to.

Marshall, A.H. The Installation of Radial Air-Cooled Engines. The Engineering Jl. (Canada), v. 15, no. 6, June 1932. p. 316-320. (figures)

Discussion of a number of features upon which successful operation of a radial air-cooled engine depends. General principles governing installation of cowling discussed. Other topics dealt with include valve temperatures, exhaust manifolds, etc., and the effect of rigidity or vibration of the engine mounting upon engine operation and reliability.

Minelli, C. Sulle Velocita Critiche degli Alberi. L'Aerotecnica, v. 12, no. 11, Nov. 1932. p. 1441-1472. (appendix, figures, equations, bibliography)

Method for determining critical speeds of shafts supported on many bearings. Consideration of a shaft supported at several points, in indifferent elastic equilibrium under the action of centrifugal force, and any given bay examined separately. Determination of the differential equation of the elastic curve and deduction of expressions of the four constants of integration at the ends of said bay. Expressions of the two tangents at the end of the bay then given. Application of method to a continuous shaft with or without cantilever bays, with or without traction or compression axial thrust, and eventually with a concentrated load in some bays. Two numerical examples of critical speeds according to method described.

Prescott, F.L. Vibration Characteristics of Aircraft Engine Crankshafts. A.C.I.C., v. 7, no. 664, Feb. 23, 1932. 20 p. Air Corps Tech. Rep. No. 3533. (figures, tables, references)

A satisfactory instrument devised for recording torsional vibration. Many tests made and vibration records taken on engines of all makes and types. Records presented and discussed. Method of calculation of vibration presented in its simplest form; results of calculations with corresponding observed frequencies tabulated. Calculation of critical ranges due to torsional vibration can be made with sufficient accuracy to make the study of great value in crankshaft design.

Schunck, T.E. Berechnung der kritischer Umlaufzahlen für die Welle eines Flugzeugmotor. Ingenieur Arch., v. 2, no. 6, Feb. 1932. p. 591-603. (figures, tables, equations, references)

Calculation of the critical speed for the torsional oscillation of a 6-cylinder aircraft engine.

Taylor, E.S. Balancing a 4-Cylinder Aircraft Engine. S.A.E. Paper, Detroit Meeting, 1932.

The disadvantages of the 4-cylinder in-line engine is asserted to be largely of the problem of vibration, this vibration being of two kinds; a linear, vertical shake and an angular oscillation about an axis parallel to the crankshaft and through the center of gravity. Mathematical formulae are developed for the design of a practical balancer for small 4-cylinder in-line aviation engines.

Allerding, W. Die hydrostatische Sandner-Kupplung und ihre Bedeutung für die Dämpfung von Drehschwingungen insbesondere bei Dieselmotoranlagen. Werft-Raederei-Hafen, v. 14, no. 17, Sept. 1, 1933. p. 242-244.

Hydrostatic Sandner coupling and its significance for damping of torsional vibrations, especially in Diesel engines. Coupling developed by Lohmann and Stolterfeld A-G, consists of a primary part attached to driving shaft and a secondary part connected with the driven shaft. This coupling, in smaller size, can also be used in airplanes.

Brunelli, P.E. Primo Contributo al Calcolo delle Velocita Critiche degli Alberi Motori. L'Aerotecnica, v. 13, no. 4, April 1933. p. 471-474. (equations)

A problem of high numerical analysis, the solution of which is connected with machine construction. Calculation advances the critical speeds of crankshafts, i.e., the rotating speed at which the crankshaft may fail. Problem consists in the calculation of the given values. It is necessary to use the various rational methods of calculation of the given values and find out which one has to be chosen for the solution of the above problem.

Capon, R.S. The Reduction of Aircraft Noise. Engineering, v. 136, no. 3537, Oct. 27, 1933. p. 475-477; no. 3538. Nov. 3. p. 503-504. (appendix, figures, tables)

Experimental work in progress at the National Physical Laboratory, the Royal Aircraft Establishment and the Air Defense Experimental Establishment directed to this end. Discusses engine and airscrew as two chief sources of noise. Another source is vibration of structure transmitted from engine. In this connection, elastic suspension of engine requires investigation. Most important source of noise from vibration is probably drumming of a panel in a sound-proofed cabin through resonance. Correction made by identifying panel with aid of vibrographs and then supporting panel in such a way as to alter its free period.

Carter, B.C. and Muir, N.S. Torsional Resonance Characteristics of a Twelve Cylinder Vee Aero Engine. British A.R.C., R. & M. No. 1304, Feb. 2, 1933. 39 p. (figures, tables, references)

Description of torsiograph investigations in conjunction with frequency calculations and consideration of minor criticals. Estimation of relative importance of the several orders of vibration for the same forcing torque and damping. Examination of the effects on the magnitudes of the vibrations that would result from increasing the Vee angle from 45 degrees to 60 degrees. Results of torsiograph tests on a Liberty engine. Analytical method for multi-crank engines, whereby damping factors are derived from torsiograms. Analysis may be applied to other engines.

Goldthwaite, J.L. Shaft Drives for Airship and Airplane Propellers. A.S.M.E.-Trans., v. 55, AER 55-17, 1933. p. 129-132. (figures)

General recognition of the possibilities of gear and shaft transmissions would free the designer from the limitations imposed by the fixed-unit power plant and appreciably broaden the field of aircraft design. Against these advantages are weight and many engineering problems. Discusses the most important problems from the standpoint of transmission design and suggests methods of meeting them. Working stresses, torsional vibration, dynamic balancing of long shafts, flexible couplings, and splines, receive attention.

Lehr, E. Schwingungen in Ventilfedern. Z.V.D.I., v. 77, no. 18, May 6, 1933. p. 457-462. (figures, tables, equations, bibliography)

Theoretical, experimental and stroboscopic study on exciting vibrations of valve springs and suggestions for eliminating them. Application to aircraft engines.

Lundquist, W.G. Torsional Vibration of Aircraft Engine Crankshafts. A.S.M.E.-Trans., v. 55, AER 55-18, 1933. p. 133-139. (figures, tables)

Results of the study of torsional vibration of aircraft engine crankshafts. Almost all engines have one or more easily detectable critical speeds for torsional crankshaft vibration. If one such critical speed should fall in the operating range of the engine, it is likely to cause trouble. Many apparently unrelated failures of engine parts can be traced to crankshaft vibration. It is therefore important that the vibration characteristics of every engine model be known, so as to intelligently develop its design for maximum reliable power output.

Mansa, J.L. Die Bestimmung der Dampfung von Drehschwingungen einer Flugmotorkurbelwellen. Dissertation-Karlsruhe Technische Hochschule, 1933. 76 p. Printed in Copenhagen, Levin and Munksgaard.

Dissertation describes and discusses critically a method used by the author to determine the damping of the torsional vibration in an airplane engine. The experimental work and the methods of calculation are described in detail.

Raleigh, W. Problems of Motor Mounting. Popular Aviation, v. 13, no. 2, Aug. 1933. p. 99. (figure)

A description of the research work, recently conducted by the National Advisory Committee for Aeronautics, on engine vibration and other elements concerned with the efficiency of planes, and comfort of passengers on air lines.

Carter, B.C. Torsional Vibration in Aero-Engines, with Particular Reference to Damping and to the Effects of Reduction Gearing. Fourth Inter. Cong. for Appl. Mech.-Proc., July 1934.

For ungeared engines, calculation of torsional critical speeds, can be made practicably during design stage. For geared engines, the agreement between calculated and observed critical speeds is not so good, due to yielding in the gears beyond the amount determinable by calculation. Data relating to this matter obtained from twisting experiments on three types of reduction gearing; epicyclic spur, epicyclic bevel and plain spur. Analysis of torsional vibrations calculations using

Lagrange's equation, in which account may be taken of inertia moments of the gears, engine and mounting, and of elastic yielding in the gear anchorage and the engine mounting. Only minor criticals occur in the operating speed range of engines with reduction gearing (except for small engines with few cylinders) which may harm the airscrew by forcing vibrations in the blades. Articulating rod systems in radial engines and their relation to criticals at operating speeds given. Particular examples of the disturbing effects of cylinder misfiring.

Constant, H. Aircraft Vibration. British A.R.C., R. & M. No. 1627, Oct. 1934. 30 p. (appendices, figurs, tables)

Summary of the progress made in researches into the source and general characteristics of aircraft vibration. Vibrograph tests were carried out on engines on the test-bed, on the hangar, and in aircraft in flight and on the ground. Calculated the forces and couples due to the engine and airscrew that are effective in producing vibration, and the magnitude of their effect was measured.

Kryloff, N. and Bogoliuboff, N. Über einige Methoden der Nichtlinearen Mechanik in ihren Anwendungen auf die Theorie der Nicht-linearen Resonanz. Schweizerische Bauzeitung, v. 103, no. 22, June 2, 1934. p. 255-257; no. 23, June 9. p. 267-270. (figures, equations, bibliography)

Applications of methods of non-linear mechanics to theory of non-linear resonance. Application of theory to study of torsional vibrations in airplane engines.

v. Schlippe, B. Schwingungsberechnung von räumlichen Maschinenfundamenten. L.F.F., v. 11, no. 2, July 3, 1934. p. 57-63. (figures, equations)

Object of paper is to obtain an insight into the laws and phenomena of vibratory processes in three-dimensional systems with special reference to engine mountings on aircraft, the considerations developed, enabling an approximate solution for the stressing of such mountings in regard to vibrations. Calculation of natural frequencies developed and the location of the natural axes deduced; a method for numerical computation. Formulae for the calculation of double symmetrical systems. The method of calculation given can be applied with certain approximations to engine mountings on aircraft. The elastic coefficients of a symmetrical lattice structure is investigated.

_______________ Scheduled Air Line Accident Reports. Air Commerce Bul., v. 7, no. 4, Oct. 15, 1935. p. 92.

The cause of the accident to the Stimson Model-A plane of the Delta Air Lines, Inc., on August 14, 1935, is disclosed. The left out-board engine was torn from the plane as a result of unbalanced condition caused by the breaking of the propeller blade. The failure occurred as the result of a resonance condition due to the natural periods of vibration of the propeller blades, engine, and engine mount coinciding with the engine speeds and the propeller pitch settings used in flight operations with this particular type and model aircraft. Corrective measures are given.

Evans, W. J. and Butcher, E. M. The Articulated Connecting Rod. Aircraft Engineering, v. 7, no. 80, Oct. 1935. p. 254-256. (figures, equations)

Various methods have been devised for dealing with the effects of the articulated rod in aero engines. The methods already devised are not suitable for practical purposes. This article gives a number of formulae which have been derived in the course of investigation of strength, balance, and torsional vibration in articulated systems, which are put forward as the most convenient and accurate.

Kindelberger, J. H. and Atwood, J. L. A Designer-Manufacturer Viewpoint of Transport-Aircraft Needs. S.A.E.-Jl. (Trans.), v. 36, no. 6, June 1935. p. 224-236. (appendices, figures, references)

This article includes a discussion of the desirable features to be included in a commercial-transport airplane. Brief discussion of the elimination of power plant vibration, p. 226. Consideration of damping means, e.g., several types of rubber-insulated connections and vibration-absorbing floor.

Lürenbaum, K. Das Treibwerk als Schwingungserreger. L.F.F., v. 11, no. 7, Jan. 14, 1935. p. 200-201.

The power plant as a source of vibration is considered. A brief description of vibration troubles and the methods of restricting them.

Wolski, K. Vibrations de Torsion des Vilebrequins. Instytut Badan Technicznich Loynictwa, Rep. No. 65, no. 1(16), 1935. p. 44-65. (figures, equations, references)

Investigation into the problem of the natural vibrations of crankshaft systems, either isolated or coupled to separate masses, the practical outcome of which was to give an approximate method of taking account of the mass (moment of inertia) of the shaft, capable of being applied to the calculation of aero engine crankshafts. Work incomplete as only the principles of the method are given without typical numerical examples. The necessary elaboration will follow.

__________ La Synchronisation Automatique des Moteurs. L'Air, no. 394, April 1, 1936.

If, in the case of a multi-engine plane, the individual power units operate at different speeds, various objectionable phenomena such as cabin noise, vibration of tail unit, etc., are liable to occur. Synchronization by revolution counter is generally not accurate enough. Problem solved in America, France, and (probably) Germany by the installation of more sensitive devices.

__________ Getting Rid of Vibration. Aeroplane, v. 50, no. 1300, April 22, 1936. p. 501. (figures)

Messrs. E. And L. Renaux, in France, developed a new form of elastic suspension as a means of damping out vibrations set up by power plant and airscrews. The Renaux Elastic Mounting makes use of the well-known shock-absorbing properties of pneumatic tires. Tests were made of mounting on the test bed and by skilled pilots on an aeroplane. Motor was fitted with a heavy metal airscrew, use of which had been hitherto prohibited because the vibrations it set up had broken a number of motor-mountings. Pilots report that after the Renaux Mounting was installed, vibration was no longer perceptible, whatever aerobatics were attempted.

__________ Crankshaft Vibration Damper. Automobile Engineer, v. 26, no. 349, Sept. 1936. p. 360. (figures)

Torsional vibration of the rotating systems of a radial aircraft engine can be prevented by applying a pendulum vibration absorber to the system. Description of the Wright vibration damper.

Anderson, F.A. Air-Cooled Radial Aircraft-Engine Installation. S.A.E.-Jl. (Trans.), v. 39, no. 3, Sept. 1936. p. 341-350. (figures, references)

This paper deals with air-cooled aircraft-engine installations. Discussion of engine mounting. The apparatus and test procedure for objectionable vibration in the structure also discussed. No attempt is made to describe any particularly new ideas in engine-installation design, but rather the paper explains the fundamental requirements for satisfactory operation of the Wright air-cooled aircraft engines.

Beilschmidt, J.L. Torsional Oscillation of Shafts. Aircraft Engineering, v. 8, no. 85, March 1936. p. 79-80. (figures)

Formulae developed for analyzing harmonic elastic distortion due to force couples which act at different points on a crankshaft, including moments due to inertia masses.

Beilschmidt, J.L. The Critical Speed of Crankshafts. Aircraft Engineering, v. 8, no. 89, July 1936. p. 191-193. (figures, equations)

Procedure for estimating whip in shafts of other than constant section incorporating rotating masses. Formulae are given for calculating the deflection due to individual loads acting at definite points and to the weight of the shaft.

Caldwell, F.W. Propeller Advances. Aeronautical Sciences-Jl., v. 3, no. 6, April 1936. p. 219.

Subject of propellers outlined to provoke discussion by other speakers. Particular reference is made to the inter-relation of propeller and power plant in regard to aerodynamics and resonance vibrations and to materials and stresses. Extensiometers for the measurement of vibration stresses are named.

Couch, H.H. Propeller-Crankshaft Vibration Problems. A.C.I.C., v. 8, no. 703, April 1936. 12 p. Air Corps Tech. Rep. No. 4163. (figures)
Also Mechanical Engineering, v. 58, no. 4, April 1936. p. 215-221.

Part I - Study of types of vibration possible in aircraft propellers. Description and photographs of typical failures. Types of crankshaft vibrations discussed with reference to their effect on propeller hubs and blades. Object is to determine the cause of propeller failures in the Air Corps. Actual tests made.

Part II -Description of several types of pick-ups developed to obtain vibration under operating conditions. Several methods of eliminating severe crankshaft and propeller vibrations proposed.

Julien, M. La Suspension Elastique des Moteurs d'Aviation. Soc. des Ingenieur de l'Automobile-Jl., v. 9, no. 7, Sept.- Oct. 1936. p. 306-311.
Also Science Aérienne, v. 6, no. 2, March-April 1937. p. 69-81. (figures, equations)

Analytical and graphical discussion of elastic rubber mounting of airplane engines for the elimination of vibrations.

Lürenbaum, K. Vibration of Crankshaft-Propeller Systems. S.A.E.-Jl. (Trans.), v. 39, no. 5, Nov. 1936. p. 469-479. (figures, equations, discussion)
Also Automotive Industries, v. 74, no. 26, June 27, 1936. p. 914-915, 917.
L.F.F., v. 13, no. 10, Oct. 12, 1936. p. 346-356.

Discrepancies between torque-stand and flight measurements of torsional vibration on the same engine may explain propeller fractures due to flexural vibration. Recent fatigue fractures of crankshafts, differing from those due to torsional vibrations must be attributed to longitudinal vibration. Degrees of freedom are discussed with a graphical summary of vibration frequencies. Vibration forms, sources, stresses and resonance are subjected to mathematical analysis. Three effective measures against vibration are given. It is proposed to separate the crankshaft and propeller through the inter-position of a flexible spring connection to obtain a crankshaft-propeller system that would be vibration free to a large degree within the operating-speed range. Such construction would permit decreased crankshaft dimensions and weight.

Taylor, E. S. Eliminating Crankshaft Torsional Vibration in Radial Aircraft Engines. S.A.E.-Jl. (Trans.), v. 38, no. 3, March 1936. p. 81-89. (figures, equations)
Also L'Aeronautique (Bulletin L'Aerotechnique), v. 18, no. 208, Sept. 1936. p. 118-123.

Elastic and inertia characteristics of the crankshaft propeller combination of a radial aircraft engine are represented mathematically and the torque given in the form of a Fourier's series for predicting the behavior of the crankshaft in torsional vibration. Limitations in previous designs of vibration dampers are pointed out and the development of the pendulum type of vibration absorber for the Wright Cyclone engine is described.

Taylor, E. S. and Morris, E. W. Harmonic Analysis of Engine Torque Due to Gas Pressure. Aeronautical Sciences-Jl., v. 3, no. 4, Feb. 1936. p. 129-131. (references)

In order to determine vibration of a body such as an airplane engine, it is necessary to know "forcing function" or unbalanced forces and torques acting upon the body as well as the mass and elastic characteristics of the body and its supporting structure. In an airplane engine, the unbalanced torque about the crankshaft axis is one of the most troublesome components of the forcing function. It causes vibration of the engine as a whole, as well as vibration of the elastic system comprising the crankshaft propellers. The variation of torque due to gas pressure is considered in this paper. Torque from a single cylinder engine is expressed as a Fourier series. Desire for more accurate results as well as for more complete information regarding the variation of the torque series with operating conditions led to the present investigation. Use of the M.I.T. Pressure Indicator with which torque can be investigated under conditions where attempts at calculation would have been useless. The method of obtaining the results herein presented are described. Mathematical.

Den Hartog, J. P. Vibration in Industry. Applied Physics-Jl., v. 8, no. 2, Feb. 1937. p. 76-83. (figures, bibliography)

A short account is given of the growth of vibration problems as a result of development in size and speed of machines. One of the most serious is that of torsional oscillations in the shafting of engines in which the torque is non-uniform (e.g. in gasoline or Diesel engines). The non-dissipative dampers of both Lanchester and Frahm (with application to aircraft engines) are described as well as the improvements made on them by Taylor and Chilton. In addition, two recent types of machine for determining the correction to be applied to a given rotor in order to make its principal axis of inertia coincide with the bearing axis are briefly described.

Tyler, M. Aircraft-Engine Installation Vibration Problems. S.A.E.-Jl. (Trans.), v. 40, no. 6, June 1937. p. 252-262. (figures, references)

Increased emphasis on vibration studies is the result of three important influence: (1) increased loading of structures; (2) broadening of the operating speed range obtained with controllable propellers; (3) increased demand for more passenger comfort. Study of the vibra-characteristics of an engine-propeller installation includes: (1) determination of the vibration spectrum of the installation; (2) study of the exciting forces set up within this combination; (3) operating conditions, i.e., the operating speeds and the power required at these various operating speeds. From these data, the engineer can predict the vibration characteristics of the installation.

# AIRCRAFT INSTRUMENT VIBRATION.

Greenhill, G. Compass Deviation in Aircraft. Part II - Compass Deviation Due to Vibration Without Friction. British A.R.C., R. & M. No. 238, Nov. 1915. p. 539-553. (figures)

Even in absence of friction, rapid vibration of the point of support of the compass must necessarily, under certain conditions, produce a deviation of large amount.

Lucas, K. Compass Deviation in Aircraft. Part III - Report on the Errors of Compasses on Aeroplanes. British A.R.C., R. & M. No. 238, April 1915. p. 554-567. (figure)

Study of errors of compass due to vibration. Modifications in design desirable with a view to their removal.

Lucas, K. Compass Deviation in Aircraft. Part IV - On a New Type of Magnetic Compass for Use in Aeroplanes. British A.R.C., R. & M. No. 238, May 1915. p. 567-575. (figures)

Methods suggested for removing errors in deviation. Anti-vibration mounting found to reduce vibration errors.

Mallock, A. Compass Deviation in Aircraft. Part I - Deviation of the Compass Due to Vibration and Friction Between the Cup and the Pivot. British A.R.C., R. & M. No. 238, May 1915. p. 536-539. (figures)

The suggestion made that one probable cause of compass deviation was engine vibration.

Wimperis, H. E. Forced Vibrations in Aeroplane Instruments. British A.R.C., R. & M. No. 685, April 1920. 10 p. (figure)

Many instruments on aircraft have pivotally mounted parts which are elastically controlled in such manner as to form a vibrating system. A summary of the calculations useful in the design of such instruments. Mathematical.

Rudy, R. On the Prevention of Vibration. Franklin Inst.-Jl., v. 202, no. 3, Sept. 1926. p. 377-379.

Elementary theory of the absorption of vibration in instruments.

Brombacher, W. G. Recent Development in Aircraft Instruments. A.S.M.E.-Trans., v. 51, AER 51-21, 1929. p. 119-128. (figures, tables, references, discussion)

Discussion of aircraft instruments in general. Included is a description of a new vibration board used for subjecting instruments to vibration. Among the operating problems, the author considers instrument-board vibration.

________________ Essais des Instruments de Bord aux Vibrations. L'Aeronautique (Bul. L'Aerotechnique), v. 12, no. 128, Jan. 1930. p. 23-25. (figures)

Vibration tests of instruments on panel-board have two purposes: (1) mechanical resistance of the tested parts. (2) stability of indications as regards accelerations and various frequencies of vibrations. Discussion of the faults encountered in operation of altimeter under vibrating conditions; graphical representation of altimeter serves to illustrate these points. Description of the Pioneer apparatus for measuring of instrument vibrations.

Steward, C. J. The Design of Aircraft Instruments. Aircraft Engineering, v. 2, no. 17, July 1930. p. 173-176. (figures)

Static balance (one of the features discussed) requires special attention in design to secure robustness of aircraft instruments. Brief discussion of some of the elements of instrument vibration.

________________ Airplane Instrument Vibration. A.S.M.E.-Trans., v. 53, AER 53-13, 1931. p. 105-109. (discussion)

The present investigation of airplane instrument vibration is one of a preliminary character only, and had for its purposes: (1) securing information on difficulties encountered in practice; (2) collecting opinions as to the possible remedies; (3) formulating suggestions for research. Analysis of replies to a questionnaire which was sent to the aviation industry.

______________ Structural Problems and the S.A.E. Aviation, v. 30, no. 10, Oct. 1931. p. 591-593. (figures)

Summary of a paper (S. J. Zand) read before the S.A.E. on measurements of amplitude of vibrations of instrument boards. Five records are reproduced. In the worst case, amplitudes appear to be about ten times those of best case. Interesting diagram showing the amplitude of vibration against engine r.p.m. for four aeroplanes. In one case synchronous speed is reached, and the record rises abruptly off the chart and descends still more abruptly beyond the critical speed.

Zand, S. J. Study of Airplane and Instrument-Board Vibration. S.A.E.-Jl., v. 29, no. 4, Oct. 1931. p. 263-279, 315. (figures, tables, references, bibliography)
Discussion S.A.E.-Jl., v. 29, no. 6, Dec. 1931. p. 477-478.

Comprehensive study of vibration, particularly with reference to instruments. Design of a "vibrograph" described in detail. Several records reproduced and interpreted. Reduced results plotted graphically. Photographs also reproduced, showing effect of vibration on several types of instruments. Application of instruments to an analysis of the vibrations of many points in a great number of airplanes, especially of the instrument boards. Paper based on 216 experiments.

Field, R. H. and Murphy, S. J. Aircraft Instruments. Engineering-Jl. (Canada), v. 15, no. 8, Aug. 1932. p. 398-403. (figures, equations, references)

Peculiar difficulties arise in case of instruments for measuring pressure, velocity, etc., owing to the very trying conditions under which they operate. Description given of difficulties of adjustment and maintenance; the effect of such adverse influences as vibration, etc. Also discussion of sources of error in altimeters, airspeed indicators, revolution indicators and compasses.

Zand, S. J. Vibration of Instrument-Board and Airplane Structure. S.A.E.-Jl. (Trans), v. 31, no. 5, Nov. 1932. p. 445-456. (figures, tables, equations, references)

Effects of vibration on different instruments are discussed and approximate maximum permissible amplitude of vibration at cruising-speed frequency for various instruments is presented in a table. Consideration given to correct design of instrument-boards and their suspension in an airplane; theory of forced vibration with damping is reviewed to show that, if not rightly chosen, shock-absorbing materials can do as much harm as good. Physiological aspect of vibration, sources of vibration, common peculiarities of vibrations from similar types of installation and miscellaneous uses of the vibrograph also discussed. Author concludes with recommendations as to further study of vibration problems in airplane design.

______________ Vibration Insulation. Aviation, v. 32, no. 3, March 1933. p. 100. (figure)

The Lord Mfg. Co., Erie, Pa., has recently applied successfully an existing type of bonded rubber mounting to airplane instrument boards and other parts. Description of plate-form mountings used to fasten instrument panels to members of the primary structure; special mountings of monel, aluminum or chromium-plated steel.

______________ Avoiding Instrument Vibration. Scientific American, v. 149, no. 4, Oct. 1933. p. 180. (figures)

The delicate airplane instruments will function correctly only if the amplitude of the instrument panel vibration is less than 4/1000". This new Sperry vibrometer consists of a relatively heavy handle (about 5 lbs. in weight) and a precision indicator gage is indicated in 1/1000". When measuring the vibration, the instrument is held in the hand and the end of the shaft is lightly pressed against the panel.

Zand, S. J. and Swisher, L. N. Anti-Vibration Mounting of Airplane Instruments. U. S. Air Services, v. 18, no. 6, June 1933. p. 26-31.
Also Aeroplane, v. 47, no. 1221, Oct. 17, 1934. p. 459-460. (figures, equations)

Several installations described to indicate amplitude before and after anti-vibration treatment. If certain rules are followed, insulation of instrument board against vibratory disturbances is easily carried out and saving will be 50% to 75% of maintenance cost of instruments.

_______________ Anti-Vibration Mountings. Flight, v. 29, no. 1426, April 23, 1936. p. 435. (figure)

Description of "plate-type" mountings as an anti-vibration measure; also of the Lord shear-type mounting which might be used for treatment of an instrument panel.

MISCELLANEOUS VIBRATION PROBLEMS RELATED TO AIRCRAFT.

Stanton, T. E. Comparison of the Air Resistance of Stationary and Vibrating Wires. Part II. British A.R.C., R. & M. No. 40, March 1911. 2 p. (figures)

Experiments made to determine the difference, if any, between the resistance of a thin steel wire placed in a uniform current of air when steady and when vibrating with a fairly high frequency.

Stuart, A. H. The Vibration of Spars. British A.R.C., R. & M. No. 386, Dec. 1917. 3 p. (figures, table)

Cause of vibration of a spar in a particular aeroplane carefully investigated. It was found that the position of interplane strut is important, and, if placed at a position corresponding to a low order harmonic, considerable vibration of the spar was experienced. Records given of oscillation of the ends of spar for different positions of strut, which point to the wisdom of avoiding any positions for the strut more remote from the free end than 30.5% of the whole length of the spar.

Cowley, W. L. and Levy, H. Critical Loading of Struts and Structures. Part V - On the Vibration and Whirling of a Shaft of Variable Flexural Rigidity. British A.R.C., R. & M. No. 485, Sept. 1918. 8 p.

Report is a continuation of subject dealt with in Part III (R. & M. No. 453), with special application to the whirling of a shaft of variable flexural rigidity. Mathematical analysis.

Cowley, W. L. and Levy, H. Critical Loading of Struts and Structures. Part III - Vibration of Spars under End Thrusts. British A.R.C., R. & M. No. 453, June 1918. 16 p.

Mathematical investigation of the effect of end thrust differing from bay to bay of the spar, upon the natural period of vibration, upon the condition of resonance and upon the distribution of bending moments and stresses in the structure.

Harris, R. G. Vibrations of Rafwires. British A.R.C., R. & M. No. 759, Nov. 1921. 24 p. (appendix, figures, tables)

Experimental and theoretical investigations of the vibrations of rafwires during "singing". Experimental work confined to the laboratory. Aerodynamic and other measurements were made. Singing appears to be due primarily to torsional vibrations of the wire in the fundamental mode. Stresses in a singing wire were calculated. Fracture is more probable under excessive tensions. Appendix discusses experiments on the subject.

Jenkins, C. F. High Frequency Fatigue Tests. British A.R.C., R. & M. no. 982, Oct. 1925. 24 p. (appendix, figures, tables)
Also Metallurgist, v. 1, Oct. 30, 1925. p. 145.

Experiments to test fatigue limit of metals at high speeds. Torsional vibrations of large amplitudes at 5000 periods were successfully produced, but the apparatus was not quite powerful enough to break the specimens, so no fatigue limits could be determined at that speed. Description of design. Results given in tables and plotted in diagrams. Theoretical treatment in appendix.

Clarke, T.W.K. and Falkner, V. M. D. M. Smith's Method for the Determination of the Transverse Frequencies of Vibration of Uniform Beams. British A.R.C., R. & M. No. 1058, April 1926. 9 p. (appendix, figures, tables)

Application of nomographic methods to the determination of frequencies of vibrations and modes of beams. (Nomographic method reproduced from an article in Engineering, Dec. 25, 1925, p. 808, by David M. Smith.)

Jenkins, C.F. and Lehmann, G. D. High Frequency Fatigue. British A.R.C., R. & M. No. 1222, Dec. 1928. (figures, tables)
Also Roy. Soc. Proc., v. 125, no. A796, Aug. 1, 1929. p. 83-119.

Object to determine the effect of frequency of alternation of stress on the fatigue limits of various metals. Tests made at frequencies up to 20,000 per sec. New apparatus developed to vibrate the specimen by air. Only measurement necessary is the amplitude of vibration at the center of the bar. Results given.

Rühl, K. H. Neuere Festigkeitsfragen im Flugzeugbau. Z.V.D.I., v. 72, no. 40, Oct. 6, 1928. p. 1403-1408. (figures, references)

Review of recent progress in the structural design of airplanes. Discussion of load factors, calculation of vibrations and air-propeller stresses, statics of metallic parts, factors of safety and materials of construction.

Wagner, R. Die Bestimmung der Dauerfestigkeit der knetbaren, veredelbaren Leichtmetallegierungen. Bericht aus dem Institute für Mechanische Technologie und Materialkunde der Technischen Hochschule zu Berlin, Heft 1. J. Springer, Berlin, 1928. (figures, tables, bibliography)

Description of a series of extensive tests of duralumin, elektron, lautal and other light alloys, undertaken to determine their durability when exposed to repeated shock and vibration. Results given in detail. Conclusions drawn will be of interest to designers of automobiles, aircraft and other structures in which light alloys are used for structural members.

Lürenbaum, K. Über die Messtechnische Untersuchung beschleunigter Bewegungsvorgänge, insbesondere über die direkte Ermittlung von Beschleunigungen mittels eines schwingungsfähigen Systems. (Masse und Feder.) D.V.L. Jahrbuch 1929, Rep. No. 120. p. 195-201. (figures, references)

Quantitative study of accelerated movements. Report of German Aeronautical Experiment Station at Adlershof. Direct determination of acceleration of vibrating system by means of acceleration measuring device; application of principle to dynamic system, aircraft in particular.

Davis, A. H. The Causes of Noise in Aircraft. Aircraft Engineering, v. 2, no. 21, Nov. 1930. p. 273-274.

Analysis of principal sources of sound with suggested remedies and palliatives, the airscrew being the most important. Engine vibrations and vibrating stay wires are among the sources. Airscrew flutter should be avoided.

Hübner, W. Anweisung für die Prüfung der Eigenschaften von Flugzeugen. Z.F.M., v. 21, no. 20, Oct. 28, 1930. p. 529-533.
Also D.V.L. Jahrbuch 1931, Rep. No. 201. p. 679-690 (figures)

Simple procedures are shown by means of which it is possible to make a qualitative test of the properties of airplanes. Instructions for tests of the sources of vibration are included.

Saurer, C. Rubber in Airplane Construction. A.S.M.E. - Trans., v. 53, AER 53-4, 1931. p. 41-43. (figures)

There are a large number of uses to which rubber can be put to use in airplane construction. Its ability to dissipate shocks and vibrations makes it useful for engine mountings, shock absorbers and propeller insulators. Other uses discussed.

______________ Helyx-Nails. Aero Digest, v. 20, no. 1, Jan. 1932. p. 64.

Brief description of Helyx-Nails, a new heavy-duty nail for aircraft builders, which makes possible a permanent attachment of wood to metal, metal to wood, and wood to wood, which will not loosen or back out under vibration.

Brenner, P. Problems Involved in the Choice and Use of Materials in Airplane Construction. N.A.C.A., Tech. Mem. No. 658, Feb. 1932. 25 p. (figures, tables, references)
Translated from Z.F.M., v. 22, no. 21, Nov. 14, 1931. p. 637-648.
Also D.V.L. Jahrbuch 1929, Rep. No. 115. p. 149-155.

Present state of the problem of materials in airplane construction on the basis of data giving the principal characteristics of different materials and showing how they affect the form of airplane parts. Included is a discussion of the vibration strengths of various materials (wood, soft steels, duralumin, magnesium alloys, etc.) as determined by fatigue bending tests and, also, tables of vibration strengths.

Hatzinger, M. Rundschau. Z.V.D.I., v. 76, no. 23, June 4, 1932. p. 563-565. (figures)

Descriptions of the various pipes and their flexible joints for the elimination of vibrations.

Sezawa, K. and Kubo, K. Measurements of the Solid Viscosities of Metals Through the Flexural Vibrations of a Bar. Aero. Res. Inst., Imp. Univ., Tokyo, Rep. No. 89, v. 7, no. 8, Dec. 1932. p. 195-231. (figures, tables, equations, references)

Coefficients of solid viscosity for aluminum, duralumin, copper and brass were determined by means of the flexural vibrations of a bar, the resistance due to damping being assumed to be proportional to the velocity of the deformation of that body. The experiment suggests that the resonance condition of an airplane is detrimental to its behavior, as no dissipation of energy is radiated outwards from its boundary, while at the same time, the damping due to internal viscosity is too small in such a body. It was shown that the damping constants of metals, even in such a high vacuum as a 1/2000 mm. of mercury column, depend on the amplitude of the vibrations. The greater the amplitude, the greater becomes the coefficient of solid viscosity.

Eisner, F. Ein neues Verfahren zur Frequenzanalyse und seine Anwendung zur Untersuchung von Flugzeuggeräuschen. Hochfrequenztechnik und Electroakustik, v. 42, no. 2, Aug. 1933. p. 53-64. (figures, bibliography)

New method of frequency analysis and its application to study of aircraft noises. The report is from D.V.L., supplementing an earlier investigation in Elektrische Nachrichten-Technik, Sept. 1932. Present method overcomes lack of selectivity of older methods and can also be applied to vibration analysis of all kinds in wide frequency limit.

Hertel, H. Dynamic Breaking Tests of Airplane Parts. N.A.C.A., Tech. Mem. No. 698, Jan. 1933. 42 p. (figures, tables)
Translated from Z.F.M., v. 22, no. 15, Aug. 14, 1931. p. 464-473; no. 16, Aug. 28. p. 489-502.
Also D.V.L. Jahrbuch 1931, Rep. No. 248. p. 142-164.

Experimental apparatus and evaluation methods developed and tried for the execution of vibration-strength tests with entire structure parts both with and without superposed static loading. Ten metal spars and spar pieces and two wooden spars were subjected to vibration breaking tests. Results given.

Yamana, M. On the Elastic Stability of Aeroplane Structures. Faculty of Engineering, Imp. Univ., Tokyo-Jl., v. 20, no. 8, 1933. p. 163-224.

Collection of six reports. One study was made on the vibration of a compressed member (reported in April 1930). All the problems studied (on the elastic stability of materials) are important in light structures such as aeroplanes. Results obtained are arranged so that practical application is easy, and some numerical calculations and experiments are added.

Andrews, P. Testing Planes for Strength. Popular Aviation, v. 14, no. 5, May 1934. (figures)

Precautions taken by airplane manufacturers to determine the strength of airplane structures for securing safety in flight. Tests for stress, strength and vibration in the Boeing and Lockheed plants are used as illustrations.

Dentan, J. La Lutte contre le Bruit dans les Avions. L'Aeronautique, v. 16, no. 176, Jan. 1934. p. 5-12. (figures, tables, references)

Review of principles of acoustics and acoustic measurements. Study of causes of noise (such as propeller noise, engine exhaust noises, vibration of panels, cables, rods) on airplanes, and suggestions of remedies.

Teichmann, F. K. Uses of Felt in Aircraft Construction. Aero Digest, v. 24, no. 2, Feb. 1934. p. 36-39. (figures, tables)

Analysis of the applications of felt in the various parts of the aircraft structure shows a variety of uses. The reasons for using this material depend upon the results desired - weather proofing, heat insulation, sound insulation, vibration damping, etc.

Volmerange, A. Construction Aeronautique et Sécurité. L'Aeronautique (Bul. l'Aerotechnique), v. 16, no. 177, Feb. 1934. p. 9-15. (figures)

General discussion of safety of various types of airplanes by the chief of aeronautic service of Bureau

Veritas. Included is a discussion of vibrations and measures for its avoidance.

______________ Overcoming Destructive Torsional Vibration. Air Corps News Letters, v. 18, no. 6, April 1,1935. p. 143.

Brief account, in review, of recent technical developments, at the Materiel Division, in overcoming destructive torsional vibration in aircraft.

______________ Do Metals "Crystallize" under Vibration? Franklin Inst.-Jl., v. 220, no. 3, Sept. 1935. p. 391-392. Also Amer. Machinist, v. 79, no. 20, Sept. 25, 1935. p. 726.

In accounts of a recent endurance flight of an airplane, publicity was given to the belief that metals may fail as result of crystallization caused by vibration in service. Article refutes this erroneous belief which probably originated in an incorrect conclusion drawn from the typical appearance of the fractured surfaces of metals that failed after having been subjected to repeated cycles of service stresses.

Brunat, H. La Sécurité de la Navigation Aériennes. Rev. du Ministère de l'Air, v. 1, no. 8, Aug. 1935. p. 1018-1030. (figures)

Statistical data on flying accidents in civil and military aviation from 1929 up to date. Accidents are stated to be due to the following: loss of speed, defects of stability, fog and other meteorological conditions; cracking up due to vibrations, oscillations, blind flying. For each of the accident causes above listed, the author presents ample technical explanations and suggestions.

House, E. R. Reducing Noise in Airplane Sound Locators. Amer. Acous. Soc.-Jl., v. 7, no. 2, Part I, Oct. 1935. p. 127-134.

Tests carried out in open air in order to generally improve performance of existing equipment. Among other things discussed are sound and vibration and transmission prevention.

Minelli, C. Problemi Aeronautici di Scienza delle Construzioni. L'Aerotecnica, v. 15, no. 9-10, Sept.-Oct. 1935. p. 915-937. (figures)

Survey made of most important problems in aeronautical construction, dividing them into the following headings: (1) wing structures; (2) other structures; (3) vibrations.

______________ Discovered New Type of Airplane Vibration. Science News Letter, v. 29, no. 787, May 9, 1936. p. 301.

"Severe type of vibration of a kind hitherto unknown in airplanes, has been discovered in a fast high-performance combat plane of the Nation's air forces. L. B. Tuckerman and W. Ramberg, of the Bureau of Standards, found and cured the fault." Statement with brief explanation.

de Bruyne, N. A. and Maas, J. N. A Property of Synthetic Resins. Aircraft Engineering, v. 8, no. 92, Oct. 1936. p. 289-290. (figure, equations, references)

Synthetic resins reinforced with fabric have proved in actual service to be resistant to disintegration from shocks and vibration. In order to investigate this property, measurements were made of energy absorbed by such materials under torsional oscillation; it was found that energy absorbed was greater than that of any other comparable materials such as wood or metal. Actual service under severe conditions has shown that airscrew blades, centrifuges for artificial silk gear wheels, and the like, can be satisfactorily made of such material.

Fiore, A. La Robusterra dei Velivoli in Relazione all'Aumento di Velocita. Rivista Aeronautica, v. 12, no. 4, April 1936. p. 55-88.

Paper suggests an additional phase of structural design which the author calls the "elastico-dynamics of aircraft" or the "theory of aircraft vibrations". Study of the various natures of possible vibrations, such as, free and forced vibrations of different parts of the airplane, influence of gusts, etc. Paper summarizes various specific problems, presenting in non-mathematical language the general conclusion reached so far.

Leiss, K. Massenausgleich von Rudern. L.F.F., v. 13, no. 12, Dec. 20, 1936. p. 430-432. (figures, equations, references)

A control surface can be balanced by means of a finite number of additional masses of equilibrium so that it remains free from rotation for particular vibration forms of the control-surface axis. Relations for the lowest number of balancing masses to be applied, and their positions and moments are derived.

Stefanutti, S. Note su un Velivolo Anti-Tradizionalista: Il Motoveleggiatore "S.S. 2". Rivista Aeronautica, v. 12, no. 5, May 1936. p. 147-170. (figures)

Excellent performance of a new type of motored glider in take-off, flight and landing, and the advantages which could be obtained with an airplane of this design in regard to efficiency of the propeller and tail plane, elimination of tail vibration, etc., briefly discussed. Construction and performance of the plane described in detail and the difficulties and defects of the canard airplane which are eliminated in the new design are discussed.

Stephens, B. C. Natural Vibration Frequencies of Structural Members as an Indication of End Fixity and Magnitude of Stress. Aeronautical Sciences-Jl., v. 4, no. 2, Dec. 1936. p. 54-60. (figures, tables, equations, references)

Experimental method for the determination of the degree of end restraint of structural members is presented together with a method for determining the magnitude of load in an axially loaded member by means of a single easily made measurement on the member as it stands in the stressed conditions. These two unknowns are made determinable by the fact that the natural vibration frequency of a structural member is a definite function of both the degree of end restraint and the axial load existing in the member. With this established, it remains to determine the actual relations existing between first, the natural vibration frequency and the end restraint of the member, and second, the natural vibration frequency and the axial load in the member.

Zand, S. J. Comfort in Air Travel. Roy. Aero. Soc.-Jl., v. 40, no. 307, July 1936. p. 524-556. (figures, tables, discussion)

Comfort attained in passenger airplanes in regard to noise, mechanical vibration and other factors. Propeller and engine-exhaust, noises and engine clatter are discussed and the forces acting on shear-type mountings for a 9-cylinder, 750 hp. radial engine are analyzed, including vertical shear, static overhang moment, engine torque and propeller thrust. A frequency analysis showing progress of noise reduction in an actual bi-motor, 18-passenger airplane given.

Zand, S. J. and Perot, G. Etude du Confort à Bord des Avions de Transport et Application Pratique à un Appareil. L'Aeronautique (Bul. l'Aerotechnique), v. 18, no. 205, June 1936. p. 69-85. (figures, tables)

Analysis on board airplanes and methods of decreasing the intensity at the sources of the noise. The elastic suspension of aircraft engines, ventilation and heating, materials used in soundproofing and the application of these methods to the soundproofing of the Breguet-Wibault 670 transport plane are discussed. A plan for soundproofing, specifications and estimates of the additional weight for soundproofing are described with results of flight tests. Long article with test results.

Fiore, A. Li Problema delle Vibrazioni dei Velivoli. L'Aerotecnica, v. 17, no. 3, March 1937. p. 187-216. (figures, references)

Theory of vibrations of airplanes in flight and method of their observation and measurement. Prevention of airplane vibrations. Performance of airplane materials and structural members under vibration.

## GENERAL VIBRATION PROBLEMS

Carrington, H. The Frequencies of Vibration of Flat Circular Plates Fixed at the Circumference. Phil. Mag., S. 6, v. 50, no. 300, Dec. 1925. p. 1261-1264. (table, equations, references)

The frequencies of the transverse symmetrical vibrations of a fixed circular plate depend on the solution of the given equation, which can be solved by interpolation from tables of Bessel functions, but the evaluation of the roots becomes increasingly troublesome and has eventually to be effected by the ascending series for the functions. It is shown that higher roots, and approximate values for the lower ones, can, however, be more easily obtained from the semi-convergent descending series for the same functions.

Cartan, E. and H. Note sur la Generation des Oscillations Entretenues. Annales des Postes, Télégraphes et Téléphones, v. 14, no. 12, Dec. 1925. p. 1196-1207.

Notes on the production of self-induced oscillations. Authors deduce general equations. Paper is mathematical and cannot be usefully abstracted.

Kimball, A. L. and Hull, E. H. Vibration Phenomena of a Loaded Unbalanced Shaft While Passing Through Its Critical Speed. A.S.M.E.-Trans., v. 47, no. 1976, 1925. p. 673-698. (figures)
Discussion Mechanical Engineering, v. 48, no. 4, April 1926. p. 380.
Also Mechanical Engineering, v. 48, no. 3, March 1926. p. 251-255.

Discussion, with experimental demonstration, of the peculiar vibration phenomena to which an unbalanced, loaded shaft is subject while passing through its critical speed. The basic theory is given from a somewhat new viewpoint, after which an experimental demonstration, which gives a quantitative check on the theory, is described.

Howland, R. C. J. The Vibrations of Rods and Shafts with Tension or End Thrust. Phil. Mag., S. 7, v. 1, no. 3, March 1926. p. 674-694. (figures, tables, equations, references)

For a rod or shaft without end-thrust or tension, a method for reducing the integration to a series of quadratures was given by Cowley and Levy. Special application of this method has been made by the author to determine the whirling speeds of a shaft carrying concentrated masses, and the same method is now applied to the more general problem of a rod or shaft under axial force. The method is illustrated by applying it to a uniform shaft and the results are compared with those given by an exact integration. An application to rods and shafts carrying concentrated masses is then made and the error in Dunkerley's rule is calculated for a number of different end thrusts and tensions. The paper is mathematical and establishes that the error in Dunkerley's rule is greater for a shaft with tension and less for one with thrust and for a shaft without longitudinal stress. For moderate values of the stress, the error is from 3.5% to 4% and is one of deficit.

Hummel, C. Kritische Drehzahlen als Folge der Nachgiebigkeit des Schmiermittels im Lager. Forschungsarbeiten auf dem Gebiete des Ingenieurwesens, Heft 287, 1926. 48 p. (figures, tables)

A study of critical speeds as results of the yielding quality of lubricants in bearings. Based on hydrodynamic bearing theory the field of force in the oil groove between the shaft and bearing is calculated, taking into consideration lateral discharge. Based on this calculation, it can be demonstrated that the equilibrial position of the shaft becomes stable or unstable depending upon whether its ratio of eccentricity, that is, the relation of its true to maximum eccentricity, is greater or less than 0.7. Vibrations occurring in the unstable area are not so dangerous as those occurring in the second critical speed. Bearings should be so designed that the area of critical occurrences should be avoided. Included is a supplementary article by A. Stodola - "Kritische Wellenstörung infolge der Nachgiebigkeit des Olpolsters im Lager".

Kohn, P. Zeichnerisches Verfahren zur Bestimmung der Torsions-Eigenschwingungszahlen von Wellen. Maschinenbau, v. 5, no. 5, March 4, 1926. p. 220-221. (figures)

Description of a graphical method, which is comparatively simple, for determining the torsional period of vibrations in shafts.

Liddicoat, R.T. Notes on the Demonstration of Synchronous Vibration and Critical Speed. Michigan Technic-(College of Engrs. and Arch., Univ. of Michigan), v. 39, no. 3, March 1926. p. 17-18, 23.

Brief remarks upon the theory represented by the demonstration model; description of the model and its operation. Model demonstrates; (1) vibration of a shaft-bearing mounted on an elastic support, when the shaft carries an unbalanced rotor; (2) whirling of an overhung shaft carrying a balanced or unbalanced rotor.

Lochner, R. The Torsional Vibration of Shafts and Shaft Systems. Inst. Elec. Engrs.-Jl., v. 65, no. 360, Dec. 1926. p. 76-30. (figures)

General theory of torsional oscillation reviewed. Method evolved, by which it is claimed the investigation of any number of vibrating masses is considerably simplified. This is done analytically; the formula obtained is expressed in the form of a curve. The curve applies not only to the case of vibration of a single mass but to a system containing any number of masses. Author works out the case of a system containing four masses connected by three lengths of shafting and finds the natural frequencies of torsional vibration for this system. Mathematical.

Schmidt, H. „ Zur Theorie der erzwungenen Schwingungen. Zeit. für Physik, v. 39, no. 5-6, Oct. 19, 1926. p. 474-489. (equations, references)

This paper deals with the theory of forced vibrations. If a system capable of vibration is subjected to the influence of variable periodic disturbing force, then vibrations peculiar to system will be continually interfered with at variable positions of superposed disturbance. Mathematical investigation of above problems where disturbing force is developed as Fourier series and solution then expressed in form of trigonometrical series based on fundamental linear superposition principle.

Van den Dungen, F.H. Les Equations Intégrales à plusieurs Paramètres et la Technique des Vibrations. Second Inter. Cong. Appl. Mech.-Proc., Sept. 1926. p. 113-118. (figures, tables, equations, bibliography)

Solution of the problems arising from vibrations through integral equations. Application of the solution to the case of one parameter, then to the case of several parameters. Example given.

Van der Pol, J.B. "Relaxation Oscillations." Phil. Mag., S. 7, v. 2, no. 11, Nov. 1926. p. 978-992. (figures, equations, references)
Also Zeit. Hochfrequenztechnik und Electroakustik, v. 28, Dec. 1926. p. 178-184.

In the first part of the paper, the author develops a theory relative to oscillations in systems with a single degree of freedom and including a negative resistance. Conditions obtained for the solution of the appropriate differential equation to be aperiodic, periodic, or quasi-periodic. For the latter case, solution obtained differs considerably from the normal approximately sine-formed solution, a pure periodic solution being found whose period is expressed by a "relaxation time" (time constant) of the system. Therefor the term "relaxation oscillation" may be given to such phenomena. It was shown that oscillations of multi-vibrators of the Abraham and Block type are examples of the general type of relaxation oscillations. It is probable that oscillations of the Wehnelt interrupter belong to the generator class of relaxation oscillations.

Adrian, W. Tagung über Schwingungsfragen in Braunschweig. Z.A.M.M., v. 7, no. 3, June 1927. p. 227-235. (references)

Report of the meeting of committee of Association of German Engineers held at Braunschweig on March 25-26, 1927. Various vibration problems were discussed.

Föppl, O. Berechnung der Biegungsschwingungszahl einer Welle, die mit mehreren Lasten behaftet ist. Z.A.M.M., v. 7, no. 1, Feb. 1927. p. 72-77. (figures, equations, references)

Computation of the period of vibration of flexible shafts bearing several loads. Derivation of mathematical formulae for shafts and beams, variously constrained and loaded, to enable machine designers to avoid condition of resonance of shaft-vibration with revolution frequency of machine.

Jeffcott, H.H. A Graphical Method for Determining the Whirling Speeds of Loaded Shafts. Phil. Mag., S. 7, v. 3, no. 16, April 1927 Suppl. p. 689-713. (figures, table, equations, reference)

The whirling speeds of a shaft, loaded at isolated points, the inertia of the shaft itself being neglected, are given by the roots of a certain determinantal equation. A systematic process of successive approximation to determine those roots explained. A method given of determining the coefficients of the equation by purely graphical methods.

Naylor, T.M. Whirling Speed of Shafts. Engineering, v. 124, no. 3222, Oct. 14, 1927. p. 474. (figures, references)

Experiments which show the presence of a decided disturbance in the motion of a rotating shaft at a speed approximately one half of the true whirling speed. Results are in agreement with mathematical deduction of Prof. Stodola.

Andrews, J.P. A Contribution to the Theory of Torsional Oscillations in Plastic Solids. Phil. Mag., S.7, v. 5, no. 31, May 1928 Suppl. p. 865-880.

The equations of motion of a torsional pendulum, the suspending wire being of plastic material, are investigated empirically. A second form of the equations, based on the assumption that the rate of plastic flow is proportional to an odd power of the elastic stresses, is shown to afford an explanation of the observed dependence of logarithmic decrement upon amplitude.

Blau, L.W. An Experimental Investigation of Forced Vibrations. Franklin Institute-Jl., v. 206, no. 3, Sept. 1928. p. 355-378. (figures, equations, references)

Derivation of equation and description of experimental arrangement which permits the investigation of forced vibrations. Photographic records shown which verify the theoretical results. In the experimental investigation, the upper extremity of a simple pendulum was moved in a simple harmonic motion and photographic records obtained of the motion of the pendulum bob. Different degrees of damping were used, ranging from very small to critical. The experimental results are in excellent agreement with the theory.

Den Hartog, J. P. The Lowest Natural Frequency of Circular Arcs. Phil. Mag., S. 7, v. 5, no. 28, Feb. 1928. p. 400-408. (figures, tables, equations, references)

Formulae are derived for the first and second natural frequencies of a part of a circular ring, hinged or clamped at its ends. It is shown that the type of vibration, in which the extension of the fibers occurs, under certain conditions may have a lower natural frequency than the non-extensional type of vibration. The results are given in the form of curves and tables.

Lemke, A. Experimentelle Untersuchungen zur W. Ritzschen Theorie der Transversalschwingungen quadratischer Platten. Annalen der Physik, v. 86, no. 5, July 28, 1928. p. 717-750. (figures, tables, equations, references, bibliography)

Experimental study of the Ritz theory of the transverse vibrations of square plates. Tables, from which the coefficients of series and period equations can be calculated, are given for several values of Poisson's ratio, 10 terms of the series being used. Two cases are also given using 6 and 15 terms, to show what may be expected of the approximation to 10.

Liénard, A. Etude des Oscillations Entretenues. Revue Génerale de l'Electricité, v. 23, May 26, 1928. p. 901-912; June 2. p. 946-954. (figures, equations, references)

A study made of the differential equation which has numerous applications to the oscillatory phenomena and has previously been treated by Janet, Cartan, Van der Pol and others for the study of self-induced oscillations. Simple graphical solution of the equation given and it is shown that, in the most general case, the oscillatory regime which can be produced is unique. The methods of evaluation of the amplitude of the oscillations as well as a lower limit for their duration are given.

Sezawa, K. Some Problems of Shocks Transmitted in Bars and Plates. Aero. Res. Inst., Imp. Univ., Tokyo, Rep. No. 45, v. 4, no. 4, Nov. 1928. p. 83-147. (figures, table, equations, references)

The transmission of shocks in bars and plates, when the material is visco-elastic, together with the behavior of such shocks when there are various kinds of boundaries or conditions, has been studied. The method of analysis in this is, in the first place, to derive the solutions in the form of wave transmissions from the modified equations of motion of bars or of plates in the case where the material is visco-elastic; secondly, to apply to these solutions various kinds of boundary conditions appropriate to respective cases. The problems contained in this are divided into two parts: (1) Shocks Transmitted in Bars; (2) Shocks Transmitted in Plates.

Soderberg, C. R. On the Practical Application of the Theory of Vibrations to Systems with Several Degrees of Freedom. Phil. Mag., S. 7, v. 5, no. 27, Jan 1928. p. 47-66. (figures, equations, references)

With a view to obtaining methods of finding rapidly such important quantities as the whirling speeds of multiple bearing shafts, critical speeds for line shaftings with several masses and problems of a similar nature in foundation design, author shows that the determinantal equation for the frequencies can be put into a standard form, and it, and the expanded equation, are written out with comparative ease. In addition to the numerical method solution, an elegant graphical method is given.

Strutt, M. J. O. Eigenschwingungen einer Saite mit Sinusförmiger Massenverteilung. Annalen der Physik, v. 85, no. 2, Jan. 25, 1928. p. 129-136. (figures, equations, references)

Problem of a vibrating chord with sinusoidal mass distribution calculated by means of Mathieu's differential equation theory. Certain of Rayleigh's fundamental principles newly formulated by means of the mathematical theory. Differential equations for a free, vibrating chord; sinusoidal equations.

Gerdien, H. Pauli, H. and Trendelenburg, F. Untersuchungen über Erschütterungsschwingungen und Geräusche. Zeit. Tech. Phys., v. 10, no.9, 1929. p. 374-378. (figures, references)

Investigation of vibration and sound. Communication from research laboratory of Siemens and Halske and Siemens and Schuckert on tests carried out by electrical method.

Halasz, P. Tengelyek Rezgése. Electrotechnika (Budapest), v. 22, no. 7-8, April 15, 1929. p. 63-78. (figures)

Discussion of the necessity of vibration in shafts. Factors producing and influencing oscillation. Methods of calculation and prevention of vibration.

Inglis, C. E. Natural Frequencies and Modes of Vibration in Beams of Non-Uniform Mass and Section. Inst. Naval Architects, v. 71, 1929. p. 145-166. (figures, discussion)

Equation of motion for free transverse vibration of beam; normal modes and "three-node" mode of vibration for beam of uniform section and varying mass; modes of vibration in beam unsymmetrically loaded.

Jeffcott, H. H. On the Vibration of Beams under the Action of Moving Loads. Phil. Mag., S. 7, v. 8, no. 48, July 1929. p. 145-166. (figures, discussion)

Method for approximate solution of problem of vibrations of beams under action of moving and fluctuating loads. Method of successive approximation is applicable to all cases in which damping forces and effective forces, due to acceleration of masses involved, exercise relatively small influence on deflection of beam in comparison with that produced by applied forces.

Küssner, H. G. Schwingungen mehrfach gestützter Stäbe mit Axialkräften. L.F.F., v. 4, no. 2, June 10, 1929. p. 63-67. (figures, equations)
Also D.V.L. Jahrbuch 1929, Rep. No. 135. p. 335-339.

Discussion of the vibration of a continuous beam under axial loads. Problem considered is the selection of a stay point which will make the critical speed as high as possible. The differential equation of the free oscillations is linear, of the fourth order, with constant coefficients, the solution of which is obtained in the usual way. Numerical values are computed and tabulated. Graphical representations exhibit clearly the relation between the frequency and the position of the stay point.

Prosad, K. A Dynamical Method for the Determination of Young's Modulus by Bending. Phil. Mag., S. 7, v. 7, no. 43, March 1929. p. 548-554. (figures, tables, references)

Measurement is made by determining the frequency of vibration of a bar of the material to which an attachment of soft iron is added, to electrically maintain the vibrations when the bar is non-magnetic.

Suyehiro, K. On the Damped Transversal Vibration of Prismatic Bars. Earthquake Res. Inst., Imp. Univ., Tokyo-Bul., v. 6, March 1929. p. 63-70. (equations, references)

The resistance to free transversal vibrations is composed of: (1) air resistance; (2) internal resistance due to solid viscosity of the material or its internal friction. The former is negligibly small and not further considered. The case is treated of a uniform straight bar with a longitudinal plane of symmetry and an expression obtained for the transversal vibrations parallel to this plane. Upper limits of frequency of the unresisted vibration are obtained. From the results obtained, the nature of the free vibrations of framed structures, towers, chimneys, etc. can be inferred.

Taylor, H. D. Shaft Behavior at Critical Speed. General Electric Review, v. 32, no. 4, April 1929. p. 194-200. (appendix, figures)

Characteristic behavior of shafts shown by small model. Marked reduction in violence of critical-speed disturbance obtained by accurate balancing. Theoretical reversal of bending of shaft in passing through critical speed confirmed by marking shaft. Stroboscopic apparatus for measuring angle of lag. Comparison of theoretical curves with test observations. Derivation of formulae.

Tiemann, R. Kinetik pseudoharmonischer Reibungsschwingungen. Z.A.M.M., v. 9, no. 2, April 1929. p. 110-130. (figures, tables, equations, references)

Explanation of pseudoharmonic vibrations, and difficulties involved in handling them. Investigation of pseudoharmonic frictional vibrations or vibrations resulting from constant friction for the purpose of developing kinetics of these movements to extent permitted by mathematical methods.

Bylund, P. J. Bidrag Till Utredning om Stavers Eller Ailars Transversalvaengninger Jaemte Kritik A. V. Lord Rayleigh's Differentialekvation. Teknisk Tidskrift (Stockholm), v. 60, no. 46, Nov. 15, 1930. p. 145-150; no. 51, Dec. 20. p. 157-160. (figures)

Transverse vibrations of bars or shafts and criticism of Rayleigh's differential equations. Nov. - Rayleigh's equation is shown to be exact under certain conditions, especially at excess vibrations or overtones, because critical speeds of short shafts are not identically alike. It is shown that new critical speeds deviate considerably from those pointed out by Stodola. Dec. - Comparison between old and new formulae and discussion which brings out the fact that most formulae are true only between certain limited ranges. Modified form of Westin's formula seems to be best solution as it continuously follows Euler's hyperbola curve.

Esau, A. and Hempel, M. Über die Eigenfrequenz von einseitig eingespannten Stäben. Zeit. Tech. Phys., v. 11, no. 1, Nov. 1930. p. 23-24.

Discussion of the natural frequency of a rod clamped at one end. A comparative study of the experimental frequencies with Rayleigh's, Kohlraush, Hort's, du Bois-Raymond's theses for beams having a concentrated mass. Authors conclude that the du Bois-Raymond formula is not reliable while that of Kohlraush is satisfactory.

Gauster, W. Über die Lösung von Schwingungsaufgaben mittels symbolischer Differentialrechnung. Arch. für Elektrotechnik, v. 24, no. 3, Sept. 27, 1930. p. 360-382. (equations)

Theoretical mathematical analysis of the solution of oscillation problems by means of symbolic differential calculus.

Hohenemser, K. Praktische Wege zur angenäherten Schwingungsberechnung elastischer Systeme. Ingenieur Arch., v. 1, no. 3, June 1930. p. 271-292. (figures, equations, references)

Methods for the calculation of vibrations of elastic systems based on integral equations given. Various applications to plates, rods, bulkheads, etc.

Kimball, A. L. Rigid Dynamics and Vibration. Mechanical Engineering, v. 52, no. 4, April 1930. p. 493-494.

Advance in engineering during past 50 years due to better understanding of an application of fundamental laws of rigid dynamics. Notes on gyroscopes, balancing, shaft vibration, vibration, lubrication.

Klotter, K. Die elastischen Querschwingungen belasteter Systeme. Third Inter. Cong. Appl. Mech.-Proc., v. 3, Aug. 1930. p. 154-160. (figures, equations, discussion)

Discussion of the elastic transverse vibrations of a loaded system. Beam vibrations made additionally interesting by a brief but excellent discussion by Southwell.

Liénard, A. M. Oscillations Auto-Entretenues. Third Inter. Cong. Appl. Mech.-Proc., v. 3, Aug. 1930. p. 173-177. (figures, equations, reference )

The name "self-induced oscillations" is given to the spontaneous oscillations resulting from a negative damping action which produce themselves in a position of equilibrium. General equation for the problem in the case of a single degree of freedom is given. A theory established from the calculations.

Miyazawa, S. Some Special Problems of the Flexural Vibrations of an Elastic Rod. Imp. Univ., Tohoku, Science Rep., v. 19, no. 1, March 1930. p. 53-67.

The separation of mass and structure of the rod considered as a problem in flexural vibration, followed by a discussion of the motion that follows the initial impulse.

Muto, K. Biegungschwingungen mit Berücksichtigung der Stabmasse und der ausseren und inneren Dämpfung. Z.A.M.M., v. 10, no. 4, July-Aug. 1930. p. 346-353. (figures, equations)

Theoretical and mathematical discussion of the Holzer theory of flexural vibrations taking into account the mass of rod and external and internal damping. Principles of free and constrained vibration and their bearing on earthquake phenomena. Numerical examples.

Newkirk, B. L. Whirling Balanced Shafts. Third Inter. Cong. Appl. Mech.-Proc., v. 3, Aug. 1930. p. 105-110. (figures, discussion)

A rotating shaft responds to vibration stimulus as it would if it were not rotating, except as gyroscopic action influences the motion. This action changes the natural frequency but in many cases the change is not considerable. Viewing a whirl as vibration in two components, it appears that a stimulus to whirling in the frequency of natural vibration or critical frequency of a shaft builds up whirling as a resonant phenomenon when the shaft speed is far from the critical speed. Two cases of this sort, which are important commercially, are discussed. This importance is enhanced by the fact that the stimulus occurs in the critical frequency, not for one shaft speed only, but for all shaft speeds above a certain limit for each shaft. Whirling due to cramping fits and to action of oil-film discussed. Remedies suggested.

v. Nicolai, E. Über den Einfluss der Torsion auf die Stabilität rotierender Wellen. Third Inter. Cong. Appl. Mech.-Proc., v. 3, Aug. 1930. p. 103-104. (references)

Calculations by the author on the influence of torsion on the stability of rotating shafts, lead to a paradoxical result. It is claimed, by theoretical calculation, that shafts running below, as well as above, their critical speeds are unstable when subjected to a torque. Since this is the case with most shafts, the result seems to be against actual experience, so that it is to be regarded very skeptically.

Ono, A. The Effect of Elasticity of the Clamped End of a Bar on the Frequency of the Lateral Vibrations. Imp. Acad., Tokyo-Proc., 1930. p. 97.

Study of the free flexural vibrations of an end of a bar elastically clamped. Camber and tangent at point encastré are linearly linked at the moment of stress and shear.

Ormondroyd, J. Mechanical Engineering and Vibration. Sibley Jl. of Engineering, v. 44, no. 5, May 1930. p. 162-163, 180, 182.

Review of the subject of vibrations in general, and the growing importance of the subject due to increasing size and speed of machinery. The influence of unbalance and varying magnetic forces on linear vibrations. Brief discussion of the vibration problems presented by the internal combustion engine and their solution.

Pöschl, T. Über Schwingungen zusammengesetzter Systeme. Electrotechnik und Maschinenbau, v. 48, no. 13, March 30, 1930. p. 295-296. (figures, equations)

Testing of Dunkerley's equation of the mass-covered string. Formula is not exact. For complex systems, however, as found in machine design, like beams, shafts, plates, pulleys, in some way covered with mass, it renders sufficiently exact value with simple means.

Pöschl, T. Über Hauptschwingungen für endliche Schwingungsweiten. Third Inter. Cong. Appl. Mech.-Proc., v. 3, Aug. 1930. p. 123-124.

On the fundamental frequencies of limited amplitudes of vibrations. Demonstration for limited amplitudes of the non-existence of natural frequencies in the exact sense.

Sander, H. Das Diagramm von Carl Runge für erzwungene Schwingungen. Ingenieur Arch., v. 1, no. 5, Dec. 1930. p. 645-647. (figures)

Vector diagram analysis of forced free vibration systems. In discussion, with aid of mathematical solution, it was proved that magnitude of vector is not constant.

Sezawa, K. On the Accumulation of Energy of High-Frequency Vibrations of an Elastic Plate on its Surface. Third Inter. Cong. Appl. Mech.-Proc., v. 3, Aug. 1930. p. 167-172. (references)

Theory of the vibrations of an elastic plate. The simplest case, in which the harmonic waves of very short wave length are propagated in one direction of the plane of a plate, already given by Rayleigh and Lamb. The extended problem, "the case of the two-dimensional vibrations or transmission", dealt with mathematically in this paper. Brief summary of principal results.

Terskikh, V. Computation of Torsional Vibrations. Vestnik Ingenieurov i Technikov, no. 12, Dec. 1930. p. 429-433. (figures, equations) (In Russian)

Original simplified method of computing torsional vibrations for use in design of shafts. Determination of natural period of vibration of system.

Van der Pol, J. B. Electrical and Mechanical Oscillations, the Period of Which is Proportional to a Time Constant (Relaxation Oscillation). Third Inter, Cong. Appl. Mech.-Proc., v. 3, Aug. 1930. p. 178-180. (references)

Relaxation oscillations as distinguished from sinusoidal oscillations. The theory is governed by non-linear differential equations. The general properties investigated. Demonstration of relaxation oscillations. Mathematical.

Warren, A. G. The Free and Forced Symmetrical Oscillations of Thin Bars, Circular Diaphragms and Annuli. Phil. Mag., S. 7, v. 9, no. 60, May 1930. p. 881-901. (figures, equations, references)

A number of applications of elastic theory are worked out within the scope of the article. The form of the solutions and the numerical relations given graphically having applications in design involving vibrating reeds and discs.

Goens, E. Über die Bestimmung des Elastizitätsmoduls von Stäben mit Hilfe von Biegungsschwingungen. Annalen der Physik, v. 11, no. 6, Nov. 10, 1931. p. 649-678. (figures, tables, equations, references)

Outline of theory of flexural vibrations of rods after Rayleigh and Timoshenko. Experimental tests of theory made at Institute of Engineering Physics of Germany.

Hempel, M. Das Verhalten einiger Werkstoffe bei dynamischer Biegungsbeanspruchung. Forschung auf dem Gebiete des Ingenieurwesens, v. 2, no. 9, Sept. 1931. p. 327-334. (figures)

Discussion of the behavior of some materials under dynamic bending stress. Preliminary tests and determination of external losses; results of damping measurements;

vibration rupture; change in frequency with increasing load. Damping of different metals, including iron, steel, brass and aluminum, is determined in relation to amplitude and fatigue stress (load-fluctuation coefficients).

Herold, W. Die Drehwechselfestigkeit verschiedener Stähle bei gleichzeitiger statischer Beanspruchung. Maschinenbau, v. 10, no. 20, Oct. 15, 1931. p. 637-643. (bibliography)

Torsional fatigue strength of various steels with simultaneous static stressing. Relations between torsional vibration strength, bending vibration strength, and static strength values. Torsional fatigue strength of ground specimens with notch; fatigue yield limit and its dependence on heat treatment.

Hill, A. G. Torsional Oscillations of Iron Wire. Phil. Mag., S. 7, v. 12, no. 77, Aug. 1931. p. 566-572. (tables, references)

The equation $Y^n(x + a) = b$ is investigated for torsional oscillations of specimens of iron wire (1) when newly drawn and (2) when the same wires have been subjected during 24 hours to torsional oscillations. Y is the extent and x the number of the oscillation; n, a and b are constants. Results show that n varies with the diameter of the wire and the initial amplitude of the oscillations. Any effect produced by the 24 hours of oscillation is entirely masked by the effect produced by the variation of the initial oscillation.

Hohenemser, K. and Prager, W. Über die Anzahl der Knotenpunkte bei erzwungenen und freien Stabschwingungen. Z.A.M.M., v. 11, no. 2, April 1931. p. 92-97. (figures, equations, references)

Theoretical mathematical discussion of the number of the panel points in forced and free rod vibrations.

Hohmann, W. Über Massenträgheitsmomente. Praktische Maschinen-Konstrukteur, v. 64, no. 12, June 25, 1931. p. 138-143.

Discussion of moments of inertia. Torsional vibration as cause of disturbances; determination of mass moment of inertia by experiments and calculation.

Howland, R.C.J. Vibrations of Revolving Shafts. Phil. Mag., S. 7, v. 12, no. 76, Aug. 1931. p. 297-311. (figures, equations)
Discussion v. 12, no. 81, Dec. 1931. p. 1189-1190.
v. 13, no. 86, April 1932. p. 862-865. (references)

Observations, by Newkirk and Kimball, of sudden instability of shafts at high speeds appear intrinsically unlikely to author, but some experimental evidence in support of the suggestion produced. Effects of internal friction considered on basis of certain not improbable assumptions. Results do not give support to Kimball's theory and alternative explanations are suggested.

Keulegan, G. H. On the Vibration of U Bars. Bur. of Standards-Jl. of Res., v. 6, no. 4, April 1931. p. 553-592. (figures)

Theoretical study of elongated and short U bars with special reference to their use as vibrators in investigations on elastic hysteresis. Formation of equation of motion of U bar; frequency of vibration of elongated bar. Ritz's method of approximation; Rayleigh's method for determining fundamental mode of vibration; effect of yoke on vibration; reproduction by single load of deformations due to vibration.

Lokchine, A. Sur les Vibrations Tournantes d'un Corps Limité par une Surface de Révolution. Inst. de France, Acad. des Sciences, Comptes Rendus, v. 192, no. 9, March 1931. p. 542-543.

Author gives a mathematical expression of the movement and introduces a mathematical expression of functions. Solving a new system of equations, necessary values as definite integrals are found.

Robertson, D. Vector Methods of Studying Mechanical Vibrations. Engineer, v. 151, no. 3920, Feb. 27, 1931. p. 230-231; no. 3921, March 6. p. 256-257; no. 3922, March 13. p. 288-289; no. 3923, March 20. p. 314-315. (figures)
Also Ingenieria Naval, v. 3, no. 26, Oct. 1931. p. 470-482; no. 27, Nov. p. 517-525. (In Spanish)

Author's aim in series of articles is to advocate more general adoption of vector method for studying of mechanical vibrations and to illustrate its merits by setting forth its application to some common problems. Feb. 27 - Elements of vibration; clock vector diagram; vector addition; displacement velocity; acceleration vectors. March 6 - Simple harmonic vibration; shimmying sine vibration. March 1 Forced vibrations, steady state; locus of displacement with variable frequency. March 20 - Forced vibrations, transient state; experimental demonstration of forced vibrations; practical conclusions.

Ryan, J. J. An Investigation of the Fundamental Critical Speeds of Multiple Shafts. Franklin Institute-Jl., v. 211, no. 2, Feb. 1931. p. 151-196. (figures, tables, equations, references)

Multiple shaft defined as a continuous shaft formed by alignment of rotating elements of several machines in which the unit shafts are rigidly coupled. Differential equations formed for rigid bearings with modifications for flexible bearings. Numerical examples worked out, tabulated and graphed.

Schwerin, E. Ein allgemeines Integrationsverfahren für quasiharmonische Schwingungsvorgänge. Zeit. Tech. Phys., v. 12, no. 2, 1931. p. 104-111. (figures, references)

A process derived for a quasi-harmonic oscillation based on the assumption that the elasticity and disturbing force curves are linear functions of the time. Process then applied for the investigation of large elasticity fluctuations. Numerical evaluations of some practical elasticity problems included with a comparison of position and width in the instability region.

Sezawa, K. On the Lateral Vibration of a Rectangular Plate Clamped at Four Edges. Aero. Res. Inst., Imp. Univ, Tokyo, Rep. No. 70, v. 6, no. 4, April 1931. p. 61-70.

Solution of the problem of the lateral vibration of a rectangular plate clamped ar four edges is obtained with a view to getting some clue regarding stiffness of a machinery bed or of a hull. Solution is obtained to satisfy the differential equation. Author also treats the problem of vibration of a rectangular plate in which a pair of opposite edges is supported and the other is clamped. These may be solved by Ritz's or other methods based on principles of energy. But, if one starts from differential equation of a plane plate, such cases can hardly be dealt with without method of analysis given in article.

Thum, A. Zur Frage der Sicherheit in der Konstruktionslehre. Z.V.D.I., v. 75, no. 23, June 6, 1931. p. 705-708. (figures, references)

The danger of failure due to vibration is generally under-rated. Critique of modern methods of design, particularly with regard to notched section effects in various constructed materials; urgent problems in materials research discussed.

Waltking, F. W. Zur Ermittlung der Eigenschwingungszahlen ebener Stabwerke. Ingenieur Arch., v. 2, no. 3, Sept. 1931. p. 247-274. (figures, tables, equations, references)

Calculation of the natural flexural frequencies of plain systems by means of a method based on Prager's equation.

Wetchinkin, - and Zwolinsky, - Critical Velocity of a Rotating Shaft under Tension. Central Aero-Hydrodynamical Inst., (Moscow), Rep. No. 75. 1931. 23 p. (figures, equations, references) (In Russian)

The authors calculate the critical velocity of a vertical rotating shaft when it is under tension. The condition of equilibrium leads to a differential equation with constant coefficients and a fourth order biquadratic equation. Authors consider three cases of a shaft supported at both ends.

Zeller, W. Stärkebestimmung von mechanischen Erschütterungen. Bauingenieur, v. 12, no. 32-33, Aug. 7, 1931. p. 586-590.

Development of original scale for expressing intensities of mechanical vibrations based on relation of power to mass unit; application of proposed scale to determination of vibration in ships, buildings, automobiles, etc.

Alexander, F. W. Decay of Torsional Oscillation of an Iron Wire; Effect of Variation of Period. Phil. Mag., S. 7, v. 13, no. 87, May 1932. p. 934-938. (tables, references)

In many cases the law of torsional oscillation of a wire can be represented by $Y^n(X + a) = b$, where n, a and b are constants for any one experiment, Y, the range of oscillation and X, the number of oscillations after torsion is applied and the wire left to itself. The length of the wire, the load on it and the torsion are constant but the moment of inertia, and so the period, are altered. Results show that n varies if the experiments are carried out at irregular intervals, but if the wire is put into the same physical state and the experiments performed on successive days, then no variation appears.

Baranow, G. Zur Berechnung der Drehschwingungszahlen. Z.V.D.I., v. 76, no. 8, Feb. 20, 1932. p. 184. (figures)

Methods of calculating torsional vibrations of shafts by reducing system with four weights to system with three or two weights. Reference to graphical method of Kutzbach.

Bouligand, G. Un Point de Technique des Vibrations. Inst. de France, Acad. des Sciences, Comptes Rendus, v. 194, no. 1, Jan. 4, 1932. p. 63-65.

Theoretical analysis of vibrations.

Colwell, R. C. The Vibrations of a Circular Plate. Franklin Institute-Jl., v. 213, no. 4, April 1932. p. 373-380. (figures, equation, references)

It is shown, by equations, that a plate may be vibrated so as to give any number of circles or radii and any combination of these circular plates vibrated with a violin bow produced only a few circles or radii. With a vacuum tube oscillator, many figures may be produced which have not been discovered before. Nodal curves from high vibrations given.

Den Hartog, J. P. The Use of Models in Vibration Research. A.S.M.E.-Trans., v. 54, APM 54-14, 1932. p. 153-156. (figures, equations)

In this paper, the theory of dynamic similarity as applied to vibration problems in mechanical engineering is discussed and a number of specific examples are given.

Den Hartog, J. P. and Mikina, S. J. Forced Vibrations with Non-Linear Spring Constant. A.S.M.E.-Trans., v. 54, APM 54-15, 1932. p. 157-164. (appendices, figures, equations, references, discussion)

In many technical applications, couplings are used which have springs in them with an initial set. In this paper, an exact theory of the forced vibrations of a system with such a coupling is given. Conclusions concerning the shift in critical speed with the amount of initial set are made. The solution obtained is compared with the existing approximate solution. The more general case of a coupling with stops is solved in an appendix.

Field, G. S. Vibrations in Solid Rods. Nature, v. 130, no. 3273, July 23, 1932. p. 130-131. (figure)

Optical analysis of vibrations in solid rods and determination of the coefficient of elastic viscosity.

Gradstein, S. and Prager, W. Beanspruchung und Formänderung von Stabwerken bei erzwungenen Schwingungen. Ingenieur Arch., v. 2, no. 6, Feb. 1932. p. 622-650. (appendices, figures, equations, references)

The technique of the dynamics of elastic systems in a state of vibration discussed. Calculation of stresses by means of Prager's equation.

Hoffmann, H. Uber das Aufstreten und die Entstehung von mechanischen Schwingungen mit mehreren Freiheitsgraden. Bauingenieur, v. 13, no. 11-12, March 11, 1932. p. 156-159.

Study of causes and modes of mechanical vibration of several degrees of freedom.

Hohenemser, K. Bemerkung über die Schwingungszahlen zusammengesetzter elastischer Systeme. Ingenieur Arch., v. 3, no. 1, March 1932. p. 89-90. (equations, references)

Calculation of the natural frequencies of composed elastic systems.

Kryloff, N. and Bogoliuboff, N. Quelques Exemples d'Oscillations Non-Linéares. Inst. de France, Acad. des Sciences, Comptes Rendus, v. 194, no. 4, March 14, 1932. p. 957-960.

Examples of non-linear vibrations. Stationary oscillations are composed of forced oscillations, oscillations proper and coupled oscillations.

Lowenstern, E. R. The Stabilizing Effect of Imposed Oscillations of High Frequency on a Dynamical System. Phil. Mag., S. 7, v. 13, no. 84, Feb. 1932 Suppl. p. 458-486. (figures, equations, references)

A mathematical paper in which the equations of motion are found for a general Lagrangean system which receives rapid oscillations. From these the equations of motion and conditions of stability are found for four cases, one of which is an inverted simple pendulum with two degrees of freedom whioh receives rapid vertical oscillations at the point of support. The method adopted differs from those previously used in that the forced vibrations are taken to be of high frequency and small amplitude from the beginning and modifications consequent on this assumption are made in the general Lagrangean equations of motion.

Mancy, J. Oscillations de Torsion des Arbres (Calcul des Amplitudes). Assoc. Technique Maritime et Aeronautique, Bul. No. 36, 1932. p. 619-659. (figures, equations, tables)

Mathematical analysis of torsional vibration in shafting with particular regard to determination of amplitude.

Morris, J. Shaft Revolution. Mechanical World, v. 92, no. 2392, Nov. 4, 1932. p. 429-430.

Analysis of existing theories of shaft revolution; principal test for stability of system is tendency of system to revert to equilibrium or steady motion after slight disturbance from it. Theories of Dunkerley and Greenhill, Chree and Jeffcott.

Prager, W. Nomographische Bestimmung der Eigenschwingungszahlen einfacher Tragwerksformen. Ingenieur Arch., v. 3, no. 3, June 1932. p. 298-299. (figures, reference)

Logarithmic nomograms for the solution of transcendental frequency equations of beams.

Rossiger, M. Die elastischen Schwingungen einer Masse, die durch eine Blattfeder gehalten wird. Annalen der Physik, S. 5, v. 15, no. 6, Dec. 6, 1932. p. 735-740. (figure, equations, table)

Discussion of elastic oscillations of a mass supported by a cantilever spring. The motion is compounded of the angular and linear velocities superposed. The equations are formed in the usual way and solved for several cases of interest.

Schuler, M. Die Berechnung der Gleichgewichtslage von gemessenen Schwingungen auf Grund der Fehlertheorie. Z.A.M.M., v. 12, no. 3, June 1932. p. 152-156. (figures, equations, references)

Calculation of equilibrium position of measured vibrations on basis of error theory.

Sezawa, K. Die Wirkung des Enddruckes auf die Biegungsschwingung eines Stabes mit innerer Dämpfung. Z.A.M.M., v. 12, no. 5, Oct. 1932. p. 275-279. (figures, equations, references)

Discussion of the effect of end pressure on bending oscillations with internal damping. Equations are formed with a term proportional to rate of shear. Approximate methods of solution are of interest, but numerical values for coefficient of viscosity, which is assumed to exist, can be regarded only as mean values.

Soderberg, C. R. On the Subcritical Speeds of the Rotating Shaft. A.S.M.E.-Trans., v. 54, APM 54-4, 1932. p. 45-52. (appendices, figures, equations, discussion)

Disturbances sometimes encountered at speeds above the fundamental whirling speed, having the fundamental frequency, are usually, and correctly, attributed to internal friction. Other disturbances frequently met with at speeds below the fundamental whirling speed, and when the motions also have the fundamental natural frequency, have been thought to be due to minute variations of the angular velocity of rotation caused by the eccentric application of gravity. The present paper discusses the latter group of phenomena, and aims to show that the cause assigned is incorrect.

Winn, C. E. Sur la Relation Entre une Suite Donée et une autre Suite Dérivée avec le même Intervalle d'Oscillation. Inst. de France, Acad. des Sciences, Comptes Rendus, v. 194, no. 24, June 1932. p. 2114-2115.

A mathematical analysis of a given series of oscillations and another derived from it having the same interval.

Winn, C. E. Sur l'Oscillation des Moyennes de Hölder et de Cesaro. Inst. de France, Acad. des Sciences, Comptes Rendus, v. 194, no. 12, March 21, 1932. p. 1057-1060. (references)

Mathematical analysis of oscillations using the methods of Hölder and Cesaro.

Baker, J. G. Self-Induced Vibrations. A.S.M.E.-Trans., v. 55, APM 55-2, 1933. p. 5-13. (appendix, figures, equations, references, discussion)

Self-induced vibrations defined. Discussion of methods of studying self-induced vibrations and description of several representative cases that have been studied by the author and his colleagues in the last few years.

Calderwood, J. Practical Notes on Vibration. Jr. Inst. of Engrs.-Jl. and Rec. of Trans., v. 43, no. 8, May 1933. p. 331-341.
Also Machinery Market, no. 1697, May 12, 1933. p. 13-14; no. 1699, May 26. p. 13-14.

Vibration problems that can be solved mathematically do not generally require use of complex and advanced mathematical methods. Good knowledge of algebra and elements of calculus sufficient. Engineer studying problem in vibration cannot safely take at random published method of solving his problem but must study the question from first principles.

Den Hartog, J. P. The Amplitude of Non-Harmonic Vibrations. Franklin Inst.-Jl., v. 216, no. 4, Oct. 1933. p. 459-473. (figures, equations references)

Two new approximate graphical solutions are given for the problem of forced vibration of an undamped, single degree of freedom vibrating system with a non-linear spring, whose characteristic is given in the form of a curve. One of these solutions gives much more accurate results than the approximation known so far.

Federhofer, K. Biegungsschwingungen eines Kreissing bei Konstanten Aussen- oder Innerdrucke. Ingenieur Arch., v. 4, no. 2, April 1933. p. 110-120. (figure, table)

Investigation of the influence of axial force upon the frequencies of the plane and space flexural vibrations of a circular ring. Circular and rectangular cross-sections of the ring are treated.

Frola, E. Su de Alcune Formule Aprossimate per la Frequenza delle Vibrazioni Trasversale delle Travi. Atti delle Realle Acad. delle Scienze di Torino, v. 69, no. 1, 1933-1934. p. 188-191. (equations, reference)

A method for determination of transverse frequencies of beams not much different from beams with constant section.

Giebe, E. and Bielschmidt, E. Experimentelle und theoretische Untersuchung über Dehnungseigenschwingungen von Stäben und Rohren. Annalen der Physik, S. 5, v. 18, no. 4, Oct. 16, 1933. p. 417-456; no. 5, Nov. p. 457-485. (figures, equations, tables, references)

Discussion of experimental and theoretical research on natural longitudinal vibrations of rods and tubes. A new theory expounded about coupling of vibrations by means of kinematic forces. Experimental researches demonstrate the theory.

Morris, J. Vibration. Automobile Engineer, v. 23, no. 306, May 1933. p. 175-176. (figure, equations, tables, references)

A simple and mathematically exact method, for all practical purposes, for the determination of the fundamental frequency of vibration of mechanical systems. Explanation of method considering the case of torsional vibration of two pulleys rigidly attached to a shaft, one end of which is fixed. Formula given.

Steinheil, A. Über die Verwendung von Reziprozitätsbeziehungen bei Untersuchung mechanischer Schwingungen. Zeit. Tech. Phys., v. 14, no. 1, 1933. p. 36-39. (figures, references)

Application of reciprocity relations in study of mechanical vibrations; reciprocity in motion and in impulses; reciprocity of forced periodical vibrations; theoretical mathematical analysis; experiments and results.

Waas, H. Gegenwartsfragen der Schwingungstechnik. Z.V.D.I., v. 77, no. 30, July 29, 1933. p. 831-832. (references)

Abstracts of papers presented at a meeting of the Committee on Mechanical Vibrations of the V.D.I., dealing with problems of vibration, fatigue strength under vibrating stresses, measurement of vibrations, decreasing vibrations by means of supplementary springing and damping, physiological reactions to vibrations, graphical treatment of vibration problems.

Bromberg, J. A Mathematical Solution of the Rotor-Balancing Problem. A.S.M.E.-Trans., v. 56, APM 56-14, 1934. p. 707-710. (appendices, figures, equations, references)
Discussion v. 57, p. 239-244.

In this paper, the author presents an accurate and easily applied method of determining, from the results of a dynamic-balancing test, the location and magnitude of the weights required to eliminate vibration in a rotating mass.

Duncan, W. J. and Collar, A. R. An Application of Matrices to Oscillation Problems. British A.R.C., R. & M. No. 1630, 1934. 5 p.

Summary of two papers: (1) A Method for the Solution of Oscillation Problems by Matrices, Phil. Mag., v. 17, no. 115, May 1934. p. 865-909; (2) Matrices Applied to the Motions of Damped Systems, Phil. Mag., v. 19, no. 125, Feb. 1935. p. 197-219. Object of the investigation was the development of arithmetical methods for the solution of problems on the small oscillations of dynamical systems with special reference to the cases where the number of degrees of freedom is large. In the first paper, the application of the method is restricted to systems where damping forces are absent, but this restriction is removed in the second paper.

Duncan, W. J. and Collar, A. R. A Method for the Solution of Oscillation Problems by Matrices. Phil. Mag., S. 7, v. 17, no. 115, May 1934. p. 865-909. (appendices, figures, equations, tables, references)

Account is given of an arithmetical process for the solution of a large class of problems on oscillations of dynamical systems. Matrix method involves fewer calculations than others, especially when only fundamental frequency is required, and can be applied to systems having a large number of degrees of freedom. Moreover the accuracy of the solution is checked automatically in the course of solution. Method is elucidated by simple problem of a triple pendulum, when method is extended to undamped systems having a finite number of degrees of freedom. Examples of application of method to various problems of aerodynamics such as the flexural oscillations of a tapered beam resembling an airscrew blade.

Erdélyi, A. Über die kleinen Schwingungen eines Pendels mit oszillierendem Aufhängepunkt. Z.A.M.M., v. 14, no. 4, Aug. 1934. p. 235-247. (figures, equations, references)

Mathematical theory of small vibrations of pendulums. Method by which axis of equilibrium can be calculated for sinusoidal oscillations of any amplitude and frequency.

Geiger, J. Die Beseitigung kritischer Torsionsdrehzahlen durch elastische Kupplungen. Werft-Raederei-Hafen, v. 15, no. 23, Dec. 1, 1934. p. 341-343.

Discussion of the removal of critical torsional periods by elastic couplings. Elementary considerations given briefly. The particular case of an elastic coupling with non-linear torsion-couple characteristic discussed graphically, and numerical results are given, also graphically, in illustration of the more important practical points of the problem.

Höger, R. Schwingungen elastischer Seile. Z.A.M.M., v. 14, no. 6, Dec. 1934. p. 361.

Research on vibration of elastic ropes fastened between two points of the same height. Examination of rope ends in radial and tangential direction by use of Hamilton's principle.

Kettenacker, L. Untersuchung mechanischer Schwinggebilde mittels elektrischer Ersatzschaltungen. Forschung auf dem Gebiete des Ingenieurwesens, v. 5, no. 2, March-April 1934. p. 67-71. (figures, references, bibliography)

Investigation of mechanical oscillating systems by means of equivalent circuits. Methods of testing natural oscillations of mechanical order, etc., by periodic excitation at certain points. It is claimed that this method provides a type of calculating machine which solves equations of high degree by physical means.

Konig, C. and Taub, J. Impact Buckling of Thin Bars in the Elastic Range Hingdd at Both Ends. N.A.C.A., Tech. Mem. No. 748, June 1934. 32 p. (figures, equations, references)
Translated from L.F.F., v. 10, no. 2, July 6, 1933. p. 55-64.

Theoretical analysis of the transverse oscillations of an originally not quite straight bar hinged at both ends and subjected to constant longitudinal force. Analysis of fundamental oscillation distinguishes three cases: shock load lower, equal to, or higher than the Eulerian load. Shock loads in buckling are divided into the period of actual shock and period of free oscillations following actual shock.

Lowan, A. N. Operational Treatment of Certain Mechanical and Electrical Problems. Phil. Mag., S. 7, v. 17, no. 116, June 1934. p. 1134-1144. (equations, references)

The following problems are considered: (1) forced vibration of a string with variable cross-section in a medium of constant damping coefficient; (2) forced vibration of a non-uniformly loaded string in vacuo; (3) electrical oscillation in transmission lines. The treatment is illustrative of the class of physical problems characterized by a partial differential equation of hyperbolic or elliptic type.

Odone, V. Onde Traversali di una Sbarra in un Mezzo Resistente Causate da Oscillazioni di un'Estremita. Atti delle Realle Acad. delle Scienze di Torino, v. 70, 1934-1935. p. 276-283. (eqations, references)

A study of transverse vibrations of a rod due to the rotating oscillations of one of its ends. Considering only one element of the rod, its resistance should be proportionate to the absolute velocity of the element itself. The elastic hysteresis should be taken into consideration as the phase difference between the elastic force and the deformation. Suggestions lead to the determination of the persistent vibratory motions of industrial buildings, ships and aircraft.

Pajus, J. Méthode Graphique d'Analyse Harmonique. Tech. Autom. et Aérienne, v. 25, no. 166, 1934. p. 65-68. (figures, tables)

Importance of the study of periodic functions in problems of vibration. The author deals with the Fourier series, applying graphical and analytical methods to analysis of vibrations.

Quade, W. Die Schwingungsvorgänge in Systemen mit zwei Freiheitsgraden. Z.A.M.M., v. 14, no. 6, Dec. 1934. p. 365-366. (equations)

Oscillation of systems with two degrees of freedom discussed. The roots of the usual quartic for the period are classified and fourteen possible combinations are obtained from changes of sign and from the presence of complex conjugate roots and of multiple roots.

Rembold, V. and Jehlicka, J. Das verhalten fedennder Kupplung bei Drehschwingungen. Forschung auf dem Gebiete des Ingenieurwesens, v. 5, no. 3, May-June 1934. p. 146-154. (figures, references)

Discussion of elastic couplings in torsional oscillations. Sectional sketches show details of the four elastic couplings used and the general layout of the experiments. Characteristics of steel spring and rubber couplings are given in numerical tables and graphically, the area of the hysteresis loops being large in the rubber couplings. An expression given for rate of loss of energy by damping.

Rolland, P. and Sorin, P. Etude d'une Méthode Utilisant le Couplage Entre Deux Systèmes Oscillants pour la Determination de la Résistance Mécanique des Constructions et la Mésure des Modules d'Elasticité. Publications Sci. et Tech. du Ministère de l'Air, no. 47, 1934. 178 p. (figures, tables)

Discussion of a method utilizing the coupling between two oscillating systems for the determination of mechanical strength of structures. The transfer of energy between two vibrating systems depends on the elastic properties of the connecting structure. An elastic "deterioration" of the structure affects the transfer characteristic. The authors hope to apply the method to a complicated structure, such as an aircraft fuselage.

Taub, J. Impact Buckling of Thin Bars in the Elastic Range. N.A.C.A., Tech. Mem. No. 749, July 1934. 60 p. (appendix, figures, tables, equations, references) Translated from L.F.F., v. 10, no. 2, July 6, 1933. p. 65-85. (D.V.L. Rep. No. 333)

Idealized process evolved for the purpose of analytical treatment of a not quite straight bar subjected to longitudinal force. This is followed by the mathematical principles for resolving the differential equation of the simplified problem.

Temple, G. Rayleigh's Principle in Engineering. Fourth Inter. Cong. Appl. Mech.-Proc., July 1934. Sectional Paper. (reference)

Rayleigh's principle affords a rapid and reasonably accurate method of calculating the critical conditions for the stability of elastic structures and their fundamental periods of vibration. The object of this paper is to examine why Rayleigh's method is so successful and to show that it can be made the basis of a method of obtaining a sequence of successive approximations which rapidly converge and which yield, even in the first two or three terms, estimates of the limiting value with small and known limits of error.

Teofilato, P. Un Limite Superiore dei Periodi Propri di Vibrazione di un Trave. Atti Pontificia Acad. delle Scienze Nuovi Lincei, v. 87, 1933-1934. p. 481-489.

Continuation of a previous study which dealt with a supported beam. The present experiments have been extended to the case of the beam fixed rigidly. The author wants to determine an expression of the upper limit of the periods of vibration, and to study the behavior of the beam when entering resonance with a given frequency.

Tuplin, W. A. The Calculation of Natural Frequencies of Torsional Vibration. Engineering, v. 137, no. 3566, May 18, 1934. p. 582-584; no. 3567, May 25, p. 611-612. (figures, tables)

A simple method given for obtaining the frequency equations for systems containing any number of rotors. Damping influences are not taken into account as they have little effect on natural frequencies.

Walther, A. Besselsche Funktionen. Z.V.D.I., v. 78, no. 44, Nov. 3, 1934. p. 1297-1299. (figures, tables, references)

Bessel functions and their relationship to vibrating strings and oscillations of a circular membrane discussed.

Donaldson, C. S. and Arnott, J. R. Simplified Calculations for Torsional Vibration Periods. Product Engineering, v. 6, no. 6, June 1935. p. 209-210.

Equation giving period of vibration in shafts, using "equivalent diameter" method.

Duncan, W. J. and Collar, A. R. Matrices Applied to the Motions of Damped Systems. Phil. Mag., S. 7, v. 19, no. 125, Feb. 1935. p. 197-219. (tables, equations, references)

The method of solving dynamical problems by matrices is extended to systems where damping and motional forces occur. As a preliminary to application of process of solution by matrices, the equation of motion in the reduced form is obtained where the dependent variables are so chosen that the time-rate of change of each such variable is equal to a homogeneous linear function of the variables. This involves auxiliary variables which are generalized momenta, or generalized velocities. In reduced equations matrix of coefficients is called dynamical matrix and modes of motion are obtained exclusively by operations with or on the matrix. A numerical example on a model aeroplane wing is given. The method is applicable to electrical and mixed electrical and mechanical systems.

Federhofer, K. Biegungsschwingungen der in ihrer Mittelbene belasteten Kreisplatte. Ingenieur Arch., v. 6, no. 1, Feb. 1935. p. 68-74. (figure, equations, tables, references)

Discussion of flexural vibrations of a plate loaded on its center. The author determines the dependency of the vibration frequencies from a radial uniform pressure. By increasing the radial pressure, the frequency decreases to zero for a critical value of the pressure. At this stage, the plate breaks. By using a radial tractive force, the frequency increases.

Föppl, O. Graphische Berechnung der Bewegungsvorgänge einer Zweigliedrigen Schwingungsanordnung mit Reibung. Z.A.M.M., v. 15, no. 1-2, Feb. 1935. p. 41-46. (figures, equations, references)

Graphical solution of velocity process of two-joint vibration system with friction.

Ikebe, T. On the Vibration of an Incomplete Circular Ring. Inst. Physical and Chemical Research, Tokyo-Science Papers, v. 27, no. 589, Sept. 1935. p. 244-262. (figures, equations, references)

Discussion of the frequency and form of vibration of incomplete circular rings with very small air gap, by two methods, the Ritz method and that of integral equation.

Jacobsen. L. S. and Jespersen, H. J. Steady Forced Vibrations of Single-Mass Systems with Symmetrical as Well as Unsymmetrical Non-Linear Restoring Elements. Franklin Inst.-Jl., v. 220, no. 4, Oct. 1935. p. 467-496. (figures, equations)

Mathematical discussion of theory; stability of motion; unsymmetrical restoring force; application of Den Hartog's method. Description of experimental apparatus; recording devices. Discussion of results and conclusions.

Jagger, J. G. Vibration of an Elastic Column. Phil. Mag., S. 7, v. 20, no. 136, Nov. 1935 Suppl. p. 997-1000.

If an elastic column be subjected to any distribution of axial forces, p per unit length, then by expressing p in the form of a Fourier series, the particle displacement $U_x$ and $f_x$ at any point along the column can be determined. The method also allows account to be taken of damping. Values of $U_x$ and $f_x$ are determined for the case of a column fixed at one end, free at the other, and subjected to a suddenly applied force.

Kasiwabara, M. Coefficient of Friction Between Vibrating Bodies. Soc. Mech. Engrs. (Japan)-Trans., v. 1, Feb. 1935. p. 45-47. (In Japanese with English abstract p. S12-S14)

Results of measurements; it is shown that these coefficients become extraordinarily small compared with those obtained at static state and that rate of decrease is proportional to frequencies of vibrations.

Lamoen, J. Etude Graphique des Vibrations des Systèmes à un Seul Degré de Liberté. Revue Universelle des Mines, v. 11, no. 7, May 1935. p. 213-226. (figures, equations)

Mathematical discussion leading to developemnt of graphical analysis of vibrations of systems with one degree of freedom.

Lowan, A. N. On Transverse Oscillations of Beams under the Action of Moving Variable Loads. Phil. Mag., S. 7, v. 19, no. 127, March 1935. p. 708-715. (equations, references, bibliography)

The problem of transverse oscillations of beams under the action of loads moving according to any arbitrarily prescribed law of motion is rigorously solved by a method presented in an earlier paper by the author.

Mason, W. P. Motion of Bar Vibrating in Flexure, Including Effects of Rotary and Lateral Inertia. Amer. Acous. Soc.-Jl., v. 6, no. 4, April 1935. p. 246-249. (figures, equations, references)

Complete theoretical solution given which shows that frequency of bar free to vibrate on both ends is asymptotic to frequency given by usual solution, neglecting rotary inertia, when ratio of width to length is small, and approaches frequency of bar in longitudinal vibration when width becomes comparable to length.

Moody, L. F. Lateral Vibration of Shafts. Product Engineering, v. 6, no. 2, Feb. 1935. p. 57-60; no. 3, March. p. 98-100; no. 4, April. p. 142-143.

Simple derivation of formulae for calculating critical speed of rotating shaft. Equations for shaft with three concentrated loads. Method of calculating static deflections and coefficients. Solution for two more typical shaft arrangements and approximate methods for calculating critical speeds.

Nomura, Y. Torsional Vibrations of Infinitely Long Circular Cylindrical Elastic Bodies. Imp. Univ., Tohoku, Science Reports, v. 24, no. 3, Aug. 1935. p. 372-390.

Vibrations produced by periodic force uniformly applied to periphery of normal section of cylinder are calculated and modifications introduced into character of vibrations by changing radius of cylinder and frequency of applied force.

Ormondroyd, J. Recent Research Work in Vibration and Sound. A.S.M.E.-Trans., v. 57, Appl. Mech., 1935. p. A103-A105.

List of papers and books on the general field of vibrations. Only those papers readily accessible to American engineers in publications usually available are included. Titles of papers listed have been translated into English while titles of books are given in the language in which they were printed.

Posener, L. Ein Beitrag zur Theorie der freien elastischen Schwingungen von Zylindern und Rohren. Annalen der Physik, S. 5, v. 22, no. 2, Feb. 7, 1935. p. 101-128. (equations, references)

Elastic equations in polar coordinates for thin tubes and a variety of boundary conditions considered with different types of vibrations. Solution of special limiting cases by Love-Timpe and Rayleigh. Coupling of longitudinal and transverse vibration exhibited. Vibrations involving expansion and torsion are separable. Love's complete solution for the latter and Pochammer's solution for the former are developed in terms of Fourier-Bessel series.

Quade, W. Über die Schwingungsvorgänge in gekoppelten Systemen. Ingenieur Arch., v. 6, no. 1, Feb. 1935. p. 15-34. (figures, equations, references)

After some generalities on transformation of coordinates, detailed consideration is restricted to two degrees of freedom. The types of motion with two degrees of freedom are classified according to the nature of the roots of the determinantal equation. Five diagrams of elastic systems illustrate different types of coupling, corresponding to different types of roots.

Shannon, J. F. The Interpretation of Some Torsiograph Records. Royal Technical College, Glasgow-Jl., v. 3, no. 3, Jan. 1935. p. 457-466. (figures, references)

Torsiograph records are sometimes so small and irregular that it becomes impossible to determine the component harmonics by the Fourier analysis. Their interpretation is greatly facilitated by considering the forced vibrations due to the main forcing impulses. Examples from practice illustrating forced vibrations with and without resonance are given, and also one in which the driving and the resisting torque variations are phased in order to give minimum vibrational energy at resonance. In the latter case, it was necessary to determine the forced vibrations in order to interpret the torsiograph records and also to appreciate the dynamical behavior of the system.

Tomotika, S. On the Transverse Vibration of a Square Plate with Four Clamped Edges. Aero. Res. Inst., Imp. Univ., Tokyo, Rep. No. 129, v. 10, Sept. 1935. p. 301-328. (equations, tables, references)
Also Phil. Mag., S. 7, v. 121, no. 142, April 1936. p. 745-760.

Object is to develop the analysis, in detail, of the above problem by calculating the frequency of the fundamental mode of transverse vibration of a square plate clamped at its four edges. This study is a continuation of a previous paper in which the problem of transverse vibration of a thin square plate with four clamped edges is discussed, which is one of the most important and interesting characteristic value problems in elastokinetics.

______________ Graphic Determination of the Natural Frequency of Torsional Oscillations. Sulzer Technical Review, no. 3, 1936. p. 14-19.

Graphs and explanations for determining analytically natural frequencies of torsional oscillation of flexible shafts loaded with masses of various moments of inertia.

Balinkin, I. A. On Transverse Vibrations of Long Rods. Phil. Mag., S. 7, V. 12, no. 139, Feb. 1936. p. 283-290. (figures, equations, references)

A simple theory is developed establishing a relation between the frequency of an oscillating long blade, its size and the elastic property of its material. Six specific cases are presented in theory and the experimental data are plotted for each case.

Borowicz, W. Analityczne Badanie drgan Walow Opartych na Trzech Tozyskach. Przeglad Mechaniczny, v. 2, no. 2, Jan. 25, 1936. p. 45-50. (figures, equations, references) (In Polish with brief German abstract)

Analytical study of vibrations of shafts supported at three points. Behavior studied at high speed shows that next to first, there is also second critical speed to be considered which has characteristics analogous to first which may be very close to first critical speed.

Bouthillon, L. Des Divers Types d'Oscillations. Soc. Française des Electriciens - Bul., v. 6, no. 62, Feb. 1936. p. 151-182. (figures, equations)

Coordination of various types of oscillations. Attempt to assemble all forms of oscillations (i.e., mechanical, acoustical, optical and electrical) in a single theory.

Concordia, C. The Use of Tensors in Mechanical Engineering Problems. General Electric Review, v. 39, no. 7, July 1936. p. 335-341. (figures, equations)

Method of tensor calculus applied to the vibration problem, general equations of elasticity, forces and displacements of interconnected bodies and gyroscopic effects.

Den Hartog, J. P. and Heiles, R. M. Forced Vibration in Non-Linear Systems with Various Combinations of Linear Springs. A.S.M.E.-Trans., v. 58, 1936. p. A127-A130. (figures)

Paper deals with single mass system containing combination of linear springs having force-displacement characteristics. Curves given.

Höger, R. Schwingungen elastischer Seile. Z.A.M.M., v. 16, no. 2, April 1936. p. 109-116. (figures, equations, references)

Calculation of the vibrations of an elastic rope suspended from two points of equal height. Assuming the position of equilibrium to be an arc of a circle, differential equations for the small vibrations are deduced by Hamilton's principle. As a numerical example, the first four characteristic vibrations are computed and figures drawn.

Morris, J. Approximate Methods for Finding Frequencies of Vibration. Roy. Aero. Soc.-Jl., v. 40, no. 311, Nov. 1936. p. 815-832. (appendix, figures)

Attempt is made to explain Rayleigh's principle and to clarify, as far as possible, the basis of the principle. Other devices for ascertaining approximate frequencies are also given and an appendix has been added on forced vibration experiments.

Ruedy, R. Propagation and Resonance of Longitudinal Waves in Prismatic Rods. Canadian Jl. of Research, v. 14, Sec. A, no. 2, Feb. 1936. p. 48-55. (figures, table, references)

For vibrations involving shearing and rotation and for those involving both distortion and dilation, the equations of motion combined with the boundary conditions yield in the simplest case a cubic equation for the resonance frequencies; its solution depends on Poisson's ratio and on the resonance frequencies $f_x$, $f_y$, $f_z$ which the rod possesses when in pure shearing motion in the direction of its three axes. Three series of resonance frequencies are obtained when $f_y$ and $f_x$ are constant and the frequencies of the overtones are inserted for $f_x$. A fourth series of resonance frequencies begins above the highest of the fundamental frequencies $f_x$, $f_y$, $f_z$.

Ruedy, R. Propagation and Resonance of Composite Waves in Prismatic Rods. Canadian Jl. of Research, v. 14, Sec. A, no. 3, March 1936. p. 66-70. (table)

By taking into account the three main terms of the equation of motion of the prismatic rod, there is obtained for the frequency a cubic equation which is in good agreement with the experimental results when the thickness of the rod is not negligible compared with its length but does not exceed about one-fifth of the length. It corresponds to the equation obtained for a system with three degrees of freedom. For a composite vibration consisting of a wave of dilation and a wave of distortion in the direction of the smallest dimension of the rod, and waves of dilation in the two other directions, the equations of motion combined with some of the boundary conditions yield another cubic equation for the resonance frequencies.

Van der Pol, B. On Oscillations. Laboratoria N. V. Philips' Gloeilampenfabrieken, Paper No. 1077, Jan. 1936. 35 p. (In Dutch)

The variety of periodic phenomena of oscillations makes it practically impossible to study them all in detail, but the science of mathematics binds them all together; the subject is covered completely by mathematical analysis.

VIBRATION MEASURING INSTRUMENTS

Beall, C. G. and Hall, C. I. A Vibration Recorder and Some of Its Applications. General Electric Review, v. 27, no. 5, May 1924. p. 297-303.

Description of a device for detecting and recording the characteristics of vibrations and tremors. One of the principal uses for this apparatus is found in the study of muscle tremors, a knowledge of which is becoming of increasing interest to the medical profession. This optical-photographic apparatus may be applied for other purposes.

Schmaltz, G. Über ein neues Verfahren zur Registrierung kleiner Schwingungen. Maschinenbau, v. 3, no. 18, June 26, 1924. p. 639-641. (figures, references)

Description of highly sensitive apparatus which can be fixed to any part of a machine for recording small vibrations. Examples of application.

______________ Instrument for Recording Vibrations - The Cambridge Vibrograph. Engineering, v. 119, no. 3087, Feb. 27, 1925. p. 271-272. (figures)

A practical exposition of the Cambridge vibrograph for measuring vibrations of the ground and of buildings, bridges and other structures. Permanent records are obtained by marking on celluloid.

______________ Observation of High Speed Mechanisms. Machinery (London), v. 27, no. 687, Nov. 26, 1925. p. 270-272. (figures)

Use of an apparatus that causes rapidly moving parts to appear stationary at any point in the cycle of movements. Arrangement of vibroscope and examples illustrating its use; determining lubrication troubles. Locating the cause and extent of excessive vibrations.

Geiger, J. Messgeräte und Verfahren zur untersuchung mechanischer Schwingungsvorgänge. First Inter. Cong. Appl. Mech.-Proc., 1925. p. 359-362.

Describes three instruments invented by the author:

1 - Torsiograph for the reproduction of the torsional vibrations of the propeller shaft.

2 - Vibrograph for the registration of the vibrations of machines, buildings, etc.
3 - General registrator for the registration of the deformation of metallic beams, static and dynamic loads, etc.

Hunt, J. H. and Embshoff, G. F. Some New Electrical Instruments for Automotive Research. S.A.E.-Jl. (Trans.), v. 16, no. 4, April 1925. p. 444-455. (appendices, figures, bibliography)

Description of instruments developed for measuring and recording engine-cylinder pressures, detecting and recording crankshaft and camshaft vibrations, and detecting the sources of noise and measuring the intensity of noise vibrations. This paper has great value because it describes the elements that have been found best suited for the desired purposes and shows how the detecting, measuring, and recording elements are combined into complete, practical working instruments. It explains how the instruments are calibrated and used and also the characteristics of the diagrams made with them.

Obata, J. and Yoshida, Y. On the Valve Method of Measuring Small Motion, with Special Reference to the Precise Recording of Sounds, Pressure-Variations, and Vibrations. Aero. Res. Inst., Imp. Univ., Tokyo, Rep. No. 11, v. 1, Aug. 1925. p. 305-319. (figures, references)

Results of a series of experiments which were carried out with a view to applying the methods of measuring very small motion, utilizing a generating circuit containing a triode to the precise recording of sounds, pressure-variation and vibration. A special instrument (ultramicrometer) constructed, which may be used for the same purposes and other problems requiring the measurement of very small displacement or motion. The capacity method, as well as the eddy current method, may be carried out, the circuit being in all cases the "tuned grid". The plate current may be balanced or a transformer may be inserted, according to the kind of problem.

Summers, C. E. Measurement of Engine Vibration Phenomena. S.A.E.-Jl. (Trans.), v. 16, no. 2, Feb. 1925. p. 163-171. (figures)
Discussion v. 16, no. 6, June 1925. p. 639-644.

In part of the article, a number of indicating and recording instruments are described for recording vibration in engines and determining its exact character. Indicator-diagrams of various kinds of vibration are shown.

Thomas, H. A. The Measurement of Mechanical Vibrations. Engineer, v. 139, no. 3604, Jan. 23, 1925. p. 102-104. (figures)

Results and details of application of the method of measuring small motions by means of an electrical arrangement. The method was described in a former issue of the same journal (Feb. 19, 1923).

Van Kempen, C. P. B. Een Toestel Tot Het Opteekenen Van Bewegingen. De Ingenieur (Hague), v. 40, no. 49, Dec. 5, 1925. p. 1033-1038. (figures)

Design and application of the Guegnon apparatus for studying the laws of dynamics and the nature of motion of vibrations; periodic, sinusoidal and other motion.

Young, L. H. An Instrument for Recording Vibrations. Mechanical Engineering, v. 47, no. 11, Nov. 1925. p. 907-908. (figures)

Description of a portable instrument for measuring and recording the amplitude and frequency of vibrations encountered in buildings, bridges and small earth tremors. Mechanical engineers will find the instrument of advantage in investigating vibrations of machinery, engines, turbines, etc., failures of machine tools due to vibrations and similar problems.

_______________ Davey Vibrometer. American Machinist, v. 64, no. 4, Jan. 28, 1926. p. 175-176. (figures)

Description of the Davey vibrometer designed for the indication and measurement of vibration.

_______________ New Machine Designed to Determine Unbalance of Flywheels. Automotive Industries, v. 54, no. 6, Feb. 11, 1926. p. 230-231. (figures)

Description of a new device built by Tinius Olsen Testing Machine Co., Phila., Pa., to balance fly-wheels. Standard dial gauges indicating vibrations are the means of determining the amount of unbalance.

______________ Measuring Oscillations by the Vibrometer. Machinery (London), v. 27, no. 700, Feb. 25, 1926. p. 715-716. (figures)

Apparatus designed by C. Schenck, Darmstadt, Germany, in order to determine the magnitude of vibrations of any object, either machine, motor, building, structure, railway car or bridge.

______________ Instruments for Studying Machine Vibrations. Marine Eng'g. and Shipping Age, v. 31, no. 5, May 1926. p. 289. (figures)

Description of two instruments designed by Peter Davey: the vibrometer, for indication and measurement of vibration; the vibroscope, for observation and study of rapidly moving parts.

Kniehahn, W. Optische Messungen an schnellaufenden Maschinen. Motorwagen, v. 29, no. 22, Aug. 10, 1926. p. 505-510. (figures)

Method of optical measurement which is said to combine the advantage of highest accuracy with greatest simplicity. Observations involve the following: (1) Do oscillations occur periodically? (2) How great is frequency of oscillations, and in what proportion to periodicity of machine? (3) Direction of oscillations, etc. (4) Types of stroboscope used.

Mershon, A. V. Vibration Recorder. A.I.E.E.-Jl., v. 45, no. 9, Sept. 1926. p. 820-823. (figures)

A vibration recorder for electrically measuring and recording small mechanical movements.

Ormondroyd, J. The Use of Vibration Instruments on Electrical Machinery. A.I.E.E.-Jl., v. 45, no. 4, April 1926. p. 330-336. (figures, references)

Several mechanical vibration instruments are described and actual problems, which these instruments have helped to solve. are mentioned. The theory of the seismographic instruments is developed between the record or indication and the motion being measured. The limitations in the accuracy of amplitudes recorded or indicated are brought out.

______________ New Olsen Balancer Operates on Electric Contact Principle. Automotive Industries, v. 57, Dec. 17, 1927. p. 912-913.

A balancing machine suitable for the rapid testing of engine crankshafts. The crankshaft is supported in two end bearings mounted on vertical pillars which are connected to base of machine by means of springs, and is free to vibrate in the transverse direction. A method is given for measuring the amount of unbalance.

Bradley, W. F. Torsional Crankshaft Vibration Seen Through Stroborama. Automotive Industries, v. 56, no. 9, March 5, 1927. p. 370-271. (figures)

Invention of French engineers allows the degree of torsion to be read while the engine is in motion. The device makes possible a more accurate examination of all moving parts.

Kniehahn, W. Messung mechanischer Schwingungen. Z.V.D.I., v. 71, no. 28, July 9, 1927. p. 997-999. (figures)

Advantages of optical methods; possibilities of practical application; application to torsional oscillations.

Oelschläger, J. Messinstrumente für Schwingungen und Erschütterungen. Motorwagen, v. 30, no. 23, Aug. 20, 1927. p. 520-522. (figures)

Theory of the measurement of vibrations developed and four vibrographs described. Wiechert compound portable seismograph (ultrasensitive, heavy and complicated) records horizontal and vertical vibrations simultaneously. Schlick pallograph (heavy and complicated) records slow vibrations. Dr. Geiger's vibrograph measures a frequency from 50 to 60,000 per min. with amplitudes down to 0.05 mm. Vibration indicator patented by Thyssen is a simple instrument.

Oelschläger, J. Erschütterungen in Arbeitsträumen, deren Festellung und Verhütung. Gesundheits-Ingenieur, v. 50, no. 50, Dec. 10, 1927. p. 905-907. (figures)

Review of American work on permissible limits of amplitudes and frequencies of vibrations. Description of the Geiger vibrograph and the Thyssen vibration indicator. Vibrograms of engine recorded in the basement and upper story of a building.

Steuding, H. Messung mechanischer Schwingungen. Z.V.D.I., v. 71, no. 18, April 30, 1927. p. 605-608.

Abstract of work awarded first prize by the Scientific Council of Verein deutscher Ingenieure for the best work on measurement of mechanical vibrations.

______________ Torsional Vibration of Crankshafts, a Description of the R.A.E. MK III Torsiograph. British A.R.C., R. & M. No. 1248, Nov. 1928. 5 p. (figures)

Description of the design and operation of the R.A.E. torsiograph. Torsional vibrations of crankshafts may be magnified and recorded in the form of a polar diagram on a photographic plate.

Hort, W. Neuere forschungen über mechanische Schwingungen. Z.V.D.I., v. 72, no. 32, Aug. 11, 1928. p. 1118-1122. (figures, references)

Theory of vibrations dealt with under three headings: (1) the loading of rotating parts in engines; (2) failures due to vibration; (3) the measurement of vibration, including noise. Vibration meters built by Geiger and Okhiusen compared.

Saller, - Dynamik und Schwingungen des Eisenbahnoberbaues. Z.V.D.I., v. 72, no. 38, Sept. 22, 1928. p. 1323-1329. (figures)

The article includes the description of the Okhiusen and Geiger instruments. Comparison of simultaneous vibration records, obtained by Geiger and Okhiusen instruments, for trains moving with velocities from 22 to 90 km. per hour.

Schwager, C. Records Transient Vibrations. Electrical World, v. 92, no. 8, Aug. 25, 1928. p. 361-362. (figures)

Torque recorder described was designed for measuring rapidly, varying torques and can be mounted on any shaft. It is an application of the electrical telemeter described in Tech. Paper No. 247, Bur. of Stand.

Thomas, H. A. and Warren, G. W. An Optical Method of Measuring Small Vibrations. Phil. Mag., S. 7, v. 5, no. 32, May 1928. p. 1125-1130. (figures)

An interferometer method of measuring small mechanical vibrations, such as those encountered in telephone diaphragms and structures, is described and its application to the measurement of the vibration of a stiff reed is considered. The essential principles of operation are described. The method can be readily adapted for the study of the vibration of light moving systems.

______________ Device Measures Automobile Jolts and Jars. Scientific American, v. 140, no. 1, Jan. 1929. p. 68-69. (figures)

Electrical instrument developed to measure and record the jolts and vibrations to which a motor vehicle is subjected. It can be mounted on any part of the vehicle. Riding qualities of individual portions of the vehicle can be segregated and measured separately. Brief description of the instrument.

Bragg, W. An Instrument for Measuring Small Amplitudes of Vibrations. Scientific Instruments-Jl., v. 6, no. 6, June 1929. p. 196-197. (figures)

Description of a device for measuring very small amplitudes of a number of vibrating diaphragms.

Donkin, W. T. and Clark, H. H. Electric Telemeter and Valve Spring Surge. S.A.E.-Jl. (Trans.), v. 24, no. 3, March 1929. p. 315-326. (figures)

Description of the electric telemeter, an excellent means for investigating the phenomenon of valve-spring surge. This equipment has made it possible to identify the cause of valve-spring surge as a resonant condition at certain speeds. Offers suggestions for further study of fatigue as the cause of failure and of internal friction as a remedy for surge.

Flaissier, M. Contribution à l'Etude des Phénomènes des Résonances dans les Vibrations de Torsion de Lignes d'Arbres. Assoc. Technique Maritime et Aeronautique, Bul. No. 34, 1930. p. 203-226. (figures)

Description of instruments which can determine the existence or non - existence of vibration in a particular case. This gives enough precise data from which the period of vibration of a given shaft can be calculated.

Foster, P. F. Modern Vibration Instruments. Machinery (London), v. 34, no. 878, Aug. 8, 1929. p. 589-591; no. 880, Aug. 22. p. 645-646; no. 885, Sept. 26. p. 821-824; v. 35, no. 891, Nov. 7. p. 169-172.

Aug. 8 - Description of vibration measuring instrument made by the Cambridge Instrument Co. Aug. 22 - Recording accelerometer, made by the Cambridge Instrument Co., used in connection with measurement of vibration; double accelerometer employed in recording simultaneously, horizontal and vertical accelerations, or alternately, accelerations in two directions at right angles in the horizontal plane. Sept. 26 - Design of pallograph, made by the Sperry Gyroscope Co., for the purpose of recording, simultaneously, the horizontal and vertical vibrations of ships on a time chart, together with a phase record of propelling machinery. The device can be used wherever vibration is caused by moving machinery. The method of recording vertical and horizontal vibrations is outlined. Explanation of the numerical work involved when large numbers of harmonics are to be evaluated. Nov. 7- Design features of the Geiger vibrograph. Development of the torsiograph.

Hoffmann, H. Einige grundsätzliche Gesichtspunkte zur messung mechanischer Schwingungen und anwendung von Schwingungsmessern. Bauingenieur, v. 10, no. 44, Nov. 1, 1929. p. 773-777. (figures)
Discussion v. 11, no. 15, April 11, 1920. p. 271-272.

Study of the characteristics of instruments for measuring vibration, frequency, acceleration, etc. Structural features of the instruments, the efficiency attainable, etc.

Hyde, J. H. and Lintern, H. R. The Vibrations of Roads and Structures. Inst. Civil Engrs.-Proc., v. 227, part I, session 1928-1929. 15 p. (figures)
Also Engineering, v. 127, no. 3289, Jan. 25, 1929. p. 102; discussion, no. 3293, Feb. 22. p. 237-238.
Canadian Engineer, v. 57, no. 8, Aug. 20, 1929. p. 327.
Roads and Road Construction, v. 7, no. 76, April 1, 1929. p. 151-153.

Description of the vertical and horizontal vibration-measuring instruments used to ascertain the magnitude and nature of the vibrations commonly obtained in the ground and structures. Gives the qualities desired in vibration instruments. Experiments with instruments described.

Jehle, F. and Spiller, W. R. Idiosyncrasies of Valve Mechanisms and Their Causes. S.A.E.-Jl. (Trans.), v. 24, no. 2, Feb. 1929. p. 133-143. (appendix, figures)

Part of the paper describes the valve-lift curve indicator which gives a photographic record of the valve-lift curve; also a spring-vibration indicator which makes a record of the actual vibration of the spring on the same film with the valve-lift curve.

Kobayashi, K. The Two Fundamental Functions of the Vibrometer and Its Application in Electro-Acoustics. Tohoku Imp. Univ., Tech. Rep., v. 8, no. 4, 1929. p. 511-531. (bibliography) (In English)

The vibrometer invented by H. Nukiyama and Matsudaira is used for measurement of mechanical impedance of a vibrating system by means of motional mutual impedance. The vibrometer is essentially the moving coil type. Theory and application of the apparatus are given.

Pabst, W. Aufzeichnen schneller Schwingungen nach dem Ritzverfahren. Z.V.D.I., v. 73, no. 46, Nov. 16, 1929. p. 1629-1633. (figures, references)
Also D.V.L.Jahrbuch 1930. Rep. No. 167. p. 31-36.

Various applications of the methods for recording vibrations by means of pin writing on soot-covered glass. Investigation of sensitivity of the recording device. Details of design.

Rathbone, T. C. Turbine Vibration and Balancing. A.S.M.E.-Trans., v. 51, APM 51-23, 1929. p. 267-284. (figures, references, discussion)

Part of paper deals with the strobo-vibroscope developed to study motion in a complex system, with results of the experiments made on a large rotor by means of this instrument.

Risch, I. Messungen von Verkehrserschütterungen. Verkehrstechnik, v. 46, no. 40, Oct. 4, 1929. p. 707-710. (figures)

Specifications for various special instruments for the determination of vibrations caused by traffic, including vibrographs, seismographs, piezoquartz and Ambronn meters.

Schlicke, H. Einige Bauarten von Schwingungsmessern. Wärme, v. 52, no. 15, April 13, 1929. p. 281-283. (figures)

Maihak, Schenk, Spindler, Hoyer, Lehman and Michels instruments are described and their wide field of application indicated.

Thoma, H. Untersuchungen an der Maschinenanlage des Luftschiffes "Graf Zeppelin". Z.V.D.I., v. 73, no. 39, Sept. 28, 1929. p. 1383-1388. (figures, references)

A method described, in part of the paper, for measuring crankshaft vibrations.

_______________ Essais des Instruments de Bord aux Vibrations. L'Aeronautique, Bul. L'Aerotechnique, v. 12, no. 128, Jan. 1930. p. 23-25. (figures)

Part of the article is devoted to a description of the Pioneer apparatus for measuring instrument vibrations.

_______________ Recent Technical Developments. Aircraft Engineering, v. 2, no. 13, March 1930. p. 61.

Included in this article is a discussion of the Geiger torsiograph and vibrograph, instruments for measuring angular and linear vibrations respectively. Brief description of each.

_______________ Measurement of Vibration. Automobile Engineer, v. 20, no. 269, July 1930. p. 283. (figures)

Apparatus designed by the Société Française Radio-Electrique of Paris for testing engines, gear-boxes, and other revolving parts in the Citroen car. The apparatus finally evolved is one in which audible vibrations are communicated to a microphone connected up to wireless amplifier. A milliameter directly records the amplitude of the mechanical vibrations.

_______________ Portable Vibrograph. Instrument World, v. 3, no. 28, Aug. 1930. p. 91-92. (figure)

Instrument designed for making spot tests of high period vibrations. Can be applied to a vibrating surface in any horizontal or vertical position. Vibrations are conveyed by a toe on the instrument and transmitted through a series of levers to a fine stylus moving over a celluloid film. An independent time record is traced.

____________ To Measure High Rotary Speeds. Aeroplane, v. 39, no. 9, Aug. 27, 1930. p. 512. (figures)

Description of the stroboscope, patented by Whidbourne and Bartrum, to measure vibrations at high speeds. Without a recorder, the instrument is used for the analysis of motion.

____________ Elektrischbatätigte Schwingungsprüfmaschine für den Maschinenbau. Zeit. für de gesamte Diessereipraxis, v. 51, no. 47, Nov. 23, 1930. p. 412-414.

Machines placed on the market by Maschinenbau Augsburg-Nürnberg can be made specially in two designs for the determination of bending and torsional vibration. Their operation described.

____________ Vibration Recorders. Electrical Review, v. 107, no. 2766, Nov. 28, 1930. p. 932.

Brief description of the Trub, Tauber miniature portable universal 3-component vibration meter, intended primarily to give a chart record of the vibration and shocks occurring on locomotives and rolling-stock. Comprises three independent miniature seismographs, each of which records one of the three components.

Ambronn, R. Über Erschütterungsmessungen und einen neuen Messer für schnelle Schwingungen. Zentralblatt der Bauverwaltung, v. 50, no. 43, Oct. 29, 1930. p. 754-757. (figures)

Principles of vibration measurement discussed. The theory and description of the original apparatus comprising electronic tube, piezo-quartz plates, gold electrodes, etc. given. Method of using the apparatus, sample of film records, etc.

v. Eberan-Eberhorst, R. Messbereichgrenzen des Torsiographen (Vibrographen). Messtechnik, v. 7, April 1930. p. 89-93.

This instrument is used for measuring torsional vibrations or the degree of irregularity of rotating shafts. A heavy mass is driven by the shaft and couples to the latter by a spring. The relative motion between mass and shaft is recorded by a finger and it is investigated how closely and within which limits the recording finger or lever follows the movements of the shaft. The theory is developed and it is found that for very high frequencies and large amplitudes the curve shows discontinuities and the lever will not follow exactly.

Geiger, J. Vibrations de Torsion des Vilebrequins et Vibrations de Flexion des Pales d'Hélices. L'Aeronautique, v. 12, no. 138, Nov. 1930. p. 403-406. (figures)

Causes and effects of vibrations and methods of their investigation with the Geiger torsiograph. Sketches and diagrams illustrate operation of the instrument.

Germond, H. H. Electronic Amplifier Tests Bearings for Vibration. Electronics, v. 1, no. 6, Sept. 1930. p. 292. (figures)

Description of the C. F. Burgess Laboratories instrument which tells with certainty the degrees of roughness in the bearing make-up.

Gyoergy, G. Egy uj rendszerű vibrográf. Electrotechnika (Budapest), v. 23, no. 21-22, Nov. 15, 1930. p. 225-241. (figures)

Measurements of mechanical vibrations. Construction arrangement, theory and parts of "Ganz" vibrograph. Possibilities of application discussed. Results of measurements.

Hoffman, H. Beitrag zur Messung und Analyse mechanischer Schwingungen. Messtechnik, July 1930. p. 131-136.

An investigation shows that the measurement of mechanical oscillations in only one component is ambiguous and does not give any indication as to how the vibration actually originated. The real character of plane vibrations can be recognized only in the polar diagram. A few illustrations show the most important characteristics of vibrations and a method for taking polar diagrams is described.

Holm, O. Die Reibungsdämpfung bei Mechanischer Schwingungsmessern. Z.A.M.M., v. 10, no. 1, Feb. 1930. p. 30-40. (figures, references)

Shows, mathematically and experimentally, the method of friction damping on vibration measuring instruments.

Malgorn, G. Les Vibrations sur les Navires. Génie Civil, v. 96, no. 11, March 15, 1930. p. 262-265. (figures)

Vibrographs for the measurement of vertical and horizontal vibrations. Results of measurements and the effect of speed of propelling machinery.

Oelschläger, J. Schwingungsprüfung von Materialen. Autom. Tech. Zeit., v. 33, no. 26, Sept. 20, 1930. p. 629-631. (figures, references)

Measurement of the resistance of shafts and crankshafts to torsional stresses by means of the Föppl-Busemann torsional vibration testing machine. Ratio of breaking stress to torsional resistance for various metals; work absorbed by metals and relation to other physical properties.

Schnauffer, K. Aufzeichnung rasch verlaufender Drukvorgänge mittels des Verfahrens der halben Resonanzkurve. L.F.F., v. 6, no. 4, Feb. 14, 1930. p. 126-136. (figures, bibliography)
Also D.V.L. Jahrbuch 1930. Rep. No. 162. p. 304-314.

Method described for recording pressure and other rapidly changing phenomena is the measuring method frequently employed in acoustics. Results of measurements are shown in the form of oscillograms and their bearing on research and design of internal-combustion engines is demonstrated.

Späth, W. Die Auswuchtung rotierender Apparateteile. Elektrotechnische Zeit., v. 51, no. 3, Jan. 16, 1930. p. 86-89. (figures, references)

Describes an electrical equipment for the determination of location and magnitude of dynamic unbalance in rotating parts which is suitable particularly where measurements of quantity production of small parts is wanted. It consists mainly in producing artificially vibrations which counteract those vibrations produced in the testing apparatus by the unbalance of the body to be balanced dynamically. A few types of such apparatus are described and their sensitivity and accuracy are discussed.

Späth, W. Dynamische Untersuchungen an Schiffen. Werft-Raederei-Hafen, v. 11, no. 5, March 7, 1930. p. 92-93. (figures)

This instrument, introduced by Losenhausenwerk of Dusseldorf, for measuring structural vibrations has proved successful in bridge and ship work and was recently used on the Bremen. It consists of two flywheels eccentrically mounted on portable framework. One motor drives the flywheels in opposite directions through reduction gearing, the purpose being to excite vibration in structures to be examined.

Spere, C. J. The McCollum-Peters Six-Element Telemeter Strain Gauge Set. A.C.I.C., v. 7, no. 657, Dec. 15, 1930. 11 p. Air Corps Tech. Rep. No. 3313. (figures)

The electric telemeter described. This instrument is used for measuring stresses in static and dynamic tests and also in flight. Proposed uses for the telemeter are given, among them being the determination of the frequency of vibration in flight of internally braced monoplane wings of metal construction.

Stern, R. Des Couples Coniques et leur Montage dans les Ponts Arrière. Soc. des Ingénieurs de l'Automobile-Jl., v. 4, no. 4, April 1930. p. 978-990. (figures)

Special mention is made of the mecascope, a testing instrument, which measures and registers differential vibration. This device differs from the microphone in that it is influenced only by the vibrations of the particular part or assemblage which it is testing.

Thoma, H. Recording Fast Oscillations. Amer. Soc. Nav. Engrs., v. 42, no. 1, Feb. 1930. p. 207-212.
Translated from Z.V.D.I., v. 73, no. 19, May 11, 1929. p. 639-642. (figures)

Description of a new method of recording, without distortion, mechanical oscillations electrically by means of high-frequency source and rectifying tube. A number of records are given. The apparatus is of importance in studying critical vibrations, since it records high frequency components of small amplitudes.

Zeller, W. Praktische und theoretische Untersuchung von Schwingungsmessern zur Aufnahme und Beurteilung von Verkehrserschütterungen. Zeit. für Bauwesen, v. 80, no. 7, July 1930. p. 171-184. (figures)
Also Verkehrstechnik, no. 52, Dec. 26, 1930. p. 199-202.

Classification of vibration recording instruments, their theory and details of construction, including seismographs, vibrographs, piezo-electric apparatus, etc. Precision of instruments; calibration; development of absolute intensity scale for rating of earthquakes and vibrations.

______________ Miniature Portable Universal Vibration Meter. Scientific Instruments-Jl., v. 8, no. 1, Jan. 1931. p. 29-31. (figures)
Also Instruments, v. 4, no. 7, July 1931. p. 402-403.
Flight, v. 23, no. 46, Nov. 13, 1931. p. 1132-1133.

A miniature 3-component vibration meter described which is intended to give a chart record of the vibration and shocks occurring on locomotives and rolling stock. This instrument should find uses in aircraft and aero engine work. The outstanding feature of the instrument is the powerful air and oil damping of the components combined with very low friction, thus avoiding any danger of resonance.

______________ New Model-3 Vibroscope. Instruments, v 4, no. 2, Feb. 1931. p. 125-126. (figure)
Also American Machinist, v. 74, no. 8, Feb. 19, 1931. p. 344.
Machinery, v. 37, no. 6, Feb. 1931. p. 486.

The vibroscope developed by the Electrocon Corp. operates on the well known stroboscopic principle. The vibroscope is applicable to the study of rotary, reciprocating or vibratory motions.

______________ Drei-Komponenten-Erschütterungsmesser mit photographischer Aufzeichnung. Z.V.D.I., v. 75, no. 28, July 11, 1931. p. 916-917. (figures)

Instrument for measuring the vibration of bridges, buildings, etc., built by Askaniawerk, Berlin, amplifying 125 to 3000 times.

_______________ Vibrograph. Instrument World, v. 4, no. 43, Nov. 1931. p. 137. (figures)

Three masses have each one degree of freedom of rotation about their axes, and transmit their motion to a plane mirror which deflects a recording point of light on a strip of sensitized paper with a magnification of ten.

Ambronn, R. Auszeichnen schneller Schwingungen. Z.V.D.I., v. 75, no. 50, Dec. 12, 1931. p. 1517-1518. (figures)

Description of Schoak's instrument for measuring vibration of machine gears, bridges, buildings, street cars, etc.

Aughtie, F. Source of Mechanical Vibration for Experimental Purposes. Phil. Mag., S. 7, v. 11, no. 70, Feb. 1931 Suppl. p. 517-522. (figures)

Following unsuccessful attempts to vibrate a loaded beam in a vertical plane, description is given of a final satisfactory method which gave controllabe amplitude up to 0.002 in. at frequencies from 8 to 35 cycles per sec. with negligible horizontal movement and a good wave form.

Bekésy, G. Über die Messung der Schwingungsamplitude fester Körper. Annalen der Physik, v. 11, no. 2, 1931. p. 227-232. (figures, references)

Description of an apparatus in which a pointer is brought into contact with a vibrating body such as the sound box of a violin. The natural period of the apparatus is readily adjustable to agree with the body, under which conditions the readily calculated maximum amplitude is substantially unaltered by contact. Diagram of connections shows a four-valve circuit with head receivers of the telephone type by which determinations are made.

Caldwell, F. W. Aspects of Airscrew Design. S.A.E. Meeting Paper (Ohio), Sept. 1-3, 1931.
Also Aviation Engineering, v. 6, no. 1, Jan. 1932. p. 14-15, 48. (figures)

Includes description of a vibrating machine designed to test failure due to propeller vibration.

Coyle, D. C. Measuring the Behavior of Tall Buildings. Engineering News Record, v. 106, no. 8, Feb. 19, 1931. p. 310-313. (figures)

A kind of seismograph is described, developed to measure the stiffness of high buildings as expressed by the amplitude of vibrations caused by wind gusts. The oscillations are recorded, and curves taken for two New York buildings are reproduced.

Davey, P. Unusual Balancing Problems: Vibration Problems. Machinery (N. Y.), v. 37, no. 5, Jan. 1931. p. 325-328. (figures)
Also Iron Age, v. 127, no. 6, Feb. 5, 1931. p. 452-455.

Description of the performance of the Davey balancing equipment (described in Iron Age, Feb. 28, 1929. p. 610). The equipment utilizes the stroboscopic principle both in the case of rotary and vibratory motions and ascertains relations of these motions to each other. The machine and vibrometer, which it includes, are described.

Doetsch, - and Mathes, - Über Schwingungmessungen an Aachen Windkanal. Abhandlungen aus dem Aerodyn. Inst., Aachen, no. 10, 1931.

In the wind tunnel the speed is not always constant, but oscillates around a medium value which is very difficult to determine, depending on the wind tunnel characteristics and its air current apparatus. To determine oscillations, the Aerodynamic Laboratory of Aachen constructed a recording apparatus which is based on the variation of the resistance of a wire by means of temperature. It consists of a wheatstone bridge with two wires of platinum heated by an electric current and facing the cooling air current of the tunnel where it records the velocity. Further description of the apparatus is given.

Geiger, J. Das Auswerten von Vibrogrammen. Messtechnik, v. 7, Oct. 1931. p. 261-267.

Explains and discusses the diagrams of vibrations taken with a vibrograph, errors which often are due to resonance phenomena, straight line and torsional vibrations, vibrograms of relative motions and the evaluation of the diagrams. From the diagram, the acceleration and the force obtained by multiplying the acceleration by the mass, can easily be calculated.

Küssner, H. G. Optico-Photographic Measurements of Airplane Deformations. N.A.C.A., Tech. Mem. No. 610, March 1931. 16 p. (figures, references)
Translated from Z.F.M., v. 21, no. 17, Sept. 15, 1930. p. 433-440.
Also D.V.L. Jahrbuch 1930. Rep. No. 194. p. 227-234.

Deformation of aircraft wings measured by photographically recording a series of bright shots on a moving paper band sensitive to light. Alternating deformations, especially vibrations, can be thus measured in operation, unaffected by inertia. Possibilities of using optographs for deformation measurements are indicated by examples. Description of apparatus. Vibration tests made with test bars at different frequencies in order to determine the damping characteristics of certain materials used.

Langer, B. F. An Instrument for Measuring Small Displacements. Rev. Scientific Instruments, v. 2, no. 6, June 1931. p. 336-342. (figures, references)

This instrument measures and records small displacements such as vibrations and strains from dynamic loads. Results of some recent development work on this instrument are given.

Mabboux, G. Sur un Oscillateur Electrique à Basse Fréquence Stabilisé par un Diapason. Inst. de France, Acad. des Science, Comptes Rendus, v. 192, no. 19, May 1931. p. 1154-1156. (figures)

Description of apparatus and its application.

Shrader, J. E. A Three-Dimensional Vibrograph. Physical Review, S. 2, v. 38, no. 10, Nov. 15, 1931. p. 1923.

A new vibrograph devised, operating on the seismographic principle, which indicates and records simultaneously in the same plane vibrations of a body in each of three directions mutually perpendicular. Description of the instrument which shows the amplitude of vibration, wave form, phase relations and frequency of the three components of vibration.

Sieber, F. An Electro-Magnetic Vibrograph. Brown-Boveri Review, v. 18, no. 8, Aug. 1931. p. 248-251. (figures)

Also Arch. für Technisches Messen, 1931. Section V 171-172. p. T49.

Remote measuring device used in the Brown-Boveri Co., Baden, over speed testing plant for measuring vibrations produced by the object under test; viz., electro-magnetic vibrograph. The equipment is briefly described; its diagrams and characteristics are given.

Späth, W. Neuere Schwingungsprüfmaschinen. Z.V.D.I., v. 75, no. 3, Jan. 17, 1931. p. 83-85. (figures, references)

Uses of the vibration measuring apparatus discussed. Testing of bridges, soil examinations, dynamic investigations of machines, buildings and aircraft. Features of several types of vibration measuring apparatus.

Stieglitz, A. Der D.V.L.-Torsiograph, ein Drehschwingungsmessgerät für Fahrzeugmotoren. Z.F.M., v. 22, no. 2, Jan. 28, 1931. p. 49-52. (figures, references, bibliography)
Also D.V.L. Jahrbuch 1931. Rep. No. 204. p. 358-361.

The D.V.L. torsiograph is easily attached to the crankshaft. A steel pointer records accurately on celluloid strip the time and rotation of the shaft. The frequency of oscillation can be obtained to the same order. The bibliography includes the Royal Aircraft Establishment torsiograph, which records optically.

Zand, S. J. A Study of Airplane and Instrument Board Vibration. S.A.E.-Jl., v. 29, no. 4, Oct. 1931. p. 263-279. 315. (figures, tables, references, bibliography)
Discussion v. 29, no. 6, Dec. 1931. p. 477-478.

Comprehensive study of vibration, particularly with reference to instruments. Design of a vibrograph described in detail. Several records reproduced and interpreted. Reduced results plotted graphically. Photographs also reproduced showing the effect of vibration on several types of instruments. Application of instruments to an analysis of the vibrations of many points in a great number of airplanes, especially of the instrument boards. The paper is based on 216 experiments.

Zeller, W. and Koch, H. W. Kritik der Aufzeichnung von Schwingungsmessern. Z.V.D.I., v. 75, no. 50, Dec. 12, 1931. p. 1509-1511. (figures, equations, references)

Derivation of fundamental errors to be considered in evaluation of vibration records made by the application of integration to differential equations valid for all vibration recorders. Results of research at the Hanover Institute of Technology.

______________ The Three Component Vibrograph. Instruments, v. 5, no. 1, Jan. 1932. p. 21. (figures)
Also Génie Civil, v. 100, no. 8, Feb. 20, 1932. p. 193-195.

Description of the three component vibrograph developed by the American Askania Corp. designed for the study of mechanical vibrations, particularly vibrations of structures. A special feature is that the vibrations are converted into visible wave forms by a mechanical-optical arrangement rather than by the use of a cathode-ray oscillograph.

______________ Stop Vibration at Its Source. Machine Design, v. 4, no. 3, March 1932. p. 26-27. (figure)

A description of a new vibration recorder. Somewhat like the seismograph for recording earthquake tremors, it measures in thousandths of an inch the vibration in steam turbines and other types of equipment.

______________ Der Pionier-Vibrograph, ein Schwingungsmesser für Flugzeuge. Z.V.D.I., v. 76, no. 17, April 23, 1932. p. 420.

On the principle of the seismograph, a beam of light is reflected onto a film carried on a rotating cylinder. By giving the source of light an axial motion, the record has a mean spiral motion and a number of spiral turns may be recorded on each film. Saving in size and weight makes the vibrograph sufficiently compact for mounting on the instrument board.

______________ Tri-Dimensional Vibrograph. Instruments, v. 5, no. 5, May 1932. p. 136. (figure)

Description of the vibrograph developed by the Vibration Specialty Co. The vibrograph is a form of the seismograph which indicates and records the components of vibration simultaneously in a vertical and two horizontal directions.

__________ Davey Model S-2 Vibrometer. American Machinist, v. 76, no. 18, May 5, 1932. p. 601-602. (figures)

Also Marine Eng'g. and Shipping Age, v. 27, no. 5, May 1932. p. 214.
Aviation Engineering, v. 7, no. 1, July 1932. p. 29.
Engineering News Record, v. 109, no. 8, Aug. 25, 1932. p. 214.
Machinery (N. Y.), v. 38, no. 9, May 1932. p. 717.

This machine is capable of measuring vertical and horizontal vibrations simultaneously. A spot of light traces the exact path of the vibration, magnified many times, on a ground glass scale. If used in conjunction with a portable balancing equipment, the machine will measure the frequency and phase position in addition to the amplitude. It indicates accurately the amplitudes of vibrations of frequencies above 400 p.m. up to 6000 p.m.

__________ Visualizing R.P.M. Aviation, v. 31, no. 8, Aug. 1932. p. 359. (figure)

Description of an instrument designed to provide visual means of obtaining propeller synchronization. Heretofore, the only method of approaching perfection in synchronizing engines on multi-engined planes has been by ear; pilots adjusting the throttle until the disappearance of audible beats indicates the vibration periods of all the engines are in phase. The new instrument provides a positive means for the perfect synchronization of propeller speeds by providing visible element by which revolutions of three engines may be tuned in perfect unison.

__________ Two-Component Vibrometer. Instruments, v. 5, no. 8, Aug. 1932. p. 193. (figure)

Description of the instrument developed by the Electrocon Corp. which measures the vertical and horizontal vibrations simultaneously when laid down on the object whose vibrations are to be measured.

Constant, H. Aircraft Vibration. Roy. Aero. Soc.-Jl., v. 36, no. 255, March 1932. p. 205-250. (figures, tables, discussion)

The article includes a description of the Cambridge vibrograph, with an example of the diagrams, and a brief discussion of the principles of analyzing them.

Fletcher, C.N. Portable Equipment for Balancing Machinery. Mechanical World, v. 92, no. 2383, Sept. 2, 1932. p. 220-221. (figures)

Description of a new vibrometer which is being adopted to measure vertical and horizontal vibrations simultaneously. The instrument works on the principle of the seismograph and marks a further development in that it provides more information and the possibility of taking photographic records.

Föppl, O. Die Wirtschaftlichkeit der Energieübertragung bei Resonanz. Z.V.D.I.,v. 76, no. 20, May 14, 1932. p. 483-484. (figures)

An example given of the Föppl-Busemann torsional vibration machine which illustrates that no economies in energy transfer can be effected by operation at resonance. Other advantages are obtainable by use of the resonance principle.

Guerbilsky, A. Enrégistrement des Déformations et des Vibrations d'une Aile d'Avion en Vol. Inst. de France, Acad. des Sciences, Comptes Rendus, v. 194, no. 3, Jan. 18, 1932. p. 249-251. (figures)

A simple process described for recording deformations and vibrations of an airplane wing in flight.

Kimball, A. L. Mésure par des Procédés Electriques de la Dissipation de l'Energie Vibratoire dans une Barre d'Acier. Congrès International d'Electricité, Comptes Rendus, v. 13, sec. 12, 1932. p. 133-144. (figures, equations, bibliography)

Measurements made of vibration damping in steel bar by electrical means. The methods used in the study of internal friction and damping are discussed. The bars were 37 m. in length and 1.25 cm. diameter. However, use of larger samples are suggested.

Klemin, A. Testing Tanks in Vibration Tables. Aviation Engineering, v. 6, no. 5, May 1932. p. 32-34.

A description of the Mitchell's flutter table capable of generating vibrations in a load of 550 kg. with a frequency of 41 Hz. and an amplitude of 3.2 mm. Navy specifications given for testing tanks in the Mitchell electric vibrating table.

Knoop, O. A. A Vibration Recording Device. Electrical West, v. 68, no. 6, May 15, 1932. p. 395-397. (figures)

Report of the sub-committee on special tests and investigations. It was found that transmission-line conductors vibrate usually at night, which necessitates the use of recording instruments. Special device is described.

Lehr, E. Schwingungsmesstechnik. Z.V.D.I., v. 76, no. 44, Oct. 29, 1932. p. 1065-1073. (figures, references)

Wide range of instruments discussed. An indicator of engine stresses measures the torsion of a crankshaft under load over the whole length or over the various crank throws.

Lürenbaum, K. Torsional Vibration of Aircraft Engines. N.A.C.A., Tech. Mem. No. 672, May 1932. 16 p. (figures, table, references)
Translated from Z.F.M., v. 23, no. 4, Feb. 29, 1932. p. 105-113.
Also D.V.L. Jahrbuch 1932. Rep. No. 268, Part IV. p. 13-21.

Included is a description of the D.V.L. torsiograph and the D.V.L. torsion recorder. Investigation of vibrations of a simple distance drive by means of the two devices is given as an example. Results and discussions of vibration tests given. Vibration damping referred to.

Pobedonoszew, J. A. Method for the Measurement of Vibrations. Central Aero-Hydrodynamical Inst., Moscow, Rep. No. 114, 1932. 37 p. (In Russian with brief English abstract)

This report is a description of a special apparatus made by the Aerodynamic Laboratory of Moscow for the measurement and registration of the pressures of a seaplane during landing and taking off. The same apparatus may be used for the registration of vibratory motions.

Späth, W. Schwingungsprüfmaschinen für Sonderzwecke. Z.V.D.I., v. 76, no. 14, April 2, 1932. p. 348-349. (figures, references)

The apparatus has four out-of-balance masses on shafts driven by two 3 h.p. motors. Forces up to 2000 kg. with a frequency up to 60 hertz. can be excited. Applications to ships and land vehicles discussed briefly.

Subra, H. Le Vibromètre. Revue Générale de l'Electricité, v. 31, no. 12, March 19, 1932. p. 371-376. (figures, bibliography)

Description of a device for the determination of electrical, mechanical and acoustical vibrations as per given equations. Theory and application of the device.

Sulzer, R. Recent Development in Diesel Engine Construction, Electro-Photographic Vibration Recorder. Inst. of Engrs. and Shipbldrs. in Scotland-Trans., v. 76, Paper No. 909, Dec. 6, 1932. p. 184-186. (figures)
Also Mechanical World, v. 94, no. 2401, Jan. 6, 1933. p. 6.

Description of a new apparatus which works in conjunction with an oscillograph. It records vibrations photographically and has the advantage of having no mechanical parts of low natural frequency.

Thomander, V. S. Characteristics of the Oscillograph-Galvanometer. Franklin Inst.-Jl., v. 213, no. 1, Jan. 1932. p. 41-55. (appendix, figures, table, equations, references)

Description of the mechanical characteristics of the vibrator for any periodic phenomena, so that the mechanical error due to the vibrator may be eliminated from the oscillogram and the true phenomena determined. The author establishes the best damping to use when considered from the standpoint of vibration response, lag and transient characteristics. The method is given for the determination of the vibrator resonance and damping that may easily be applied in the field. Curves, from which all the above mentioned may be obtained, are supplied.

Tirunarayanachar, T. An Improved Vibrograph and Some of Its Uses. Rev. Scientific Instruments, v. 3, no. 12, Dec. 1932. p. 766-776. (figures, diagrams)

Deals with a simple form of vibrograph in which a spring drum controls the motion of the photographic plate, and the slit widths and lengths are adjustable. It is shown how the vibrograph can be used for rough comparisons of the frequencies of tuning forks, and for the approximate determinations of the frequency of alternating currents, and of acceleration due to gravity.

Van Steewen, O. P. Measuring Vibration and Eliminating It. American Machinist, v. 76, no. 11, March 17, 1932. p. 353-355. (figures)

In part of the paper a discussion is given of vibration-its sources and consequences. A description of a vibration meter is included.

Warner, D. M. Special Methods of Testing Aircraft Materials. A.S.M.E.-Trans., v. 54, AER 54-17, 1932. p. 141-149. (figures)

Presents a study of the special methods employed at the Wright Field in the mechanical testing of characteristic aircraft materials and construction, together with a practical exposition of the special equipment developed. Included among the tests are the vibration of streamline wires with plain and knife edge terminals under tension. The importance of simulating service conditions, especially in all tests involving endurance in any form, is heavily stressed.

Zand, S. J. Vibration of Instrument Board and Airplane Structure. S.A.E.-Jl. (Trans.), v. 31, no. 5, Nov. 1932. p. 445-456. (figures, tables, equations, references)

Includes description of a new and improved three-component vibrograph with which separate vibrograms of the three components can be obtained simultaneously and with considerable magnification. Short mathematical analysis is given to show the fundamental differences between vibrographs and accelerometers.

Zur Capellen, W. M. Die Theorie des Frahmschen Schwingungsdaueranzeigers. Annalen der Physik, S. 5, v. 15, no. 1, Oct. 11, 1932. p. 1-27. (figures, equations, references)

Theory given of the vibration frequency indicator by Frahm. Discussion of the general equation of motion of a vibrating tongue with respect to the method of resonant excitation from rotating machinery.

________________ Westinghouse Portable Vibrometer. American Machinist, v. 77, no. 4, Feb. 15, 1933. p. 129. (figure) Also Automotive Industries, v. 68, no. 19, May 13, 1933. p. 592.

This instrument developed by the Westinghouse Electric & Mfg. Co., E. Pittsburgh, Pa., for vibration studies on small machines can be used for frequencies as high as 6000 r.p.m. when the amplitude does not exceed 0.004 in. Description of the vibrometer.

______________ Portable Vibrometer. Instruments, v. 6, no. 5, May 1933. p. 102. (figure)

Description of the portable vibrometer developed by the Starret Co. for power plant, field and service work and for general testing. Laboratory tests show that the vibrometer is reliable for frequencies as high as 6000 r.p.m. when the amplitude does not exceed 0.004 in., and at lower speeds for much higher amplitudes.

______________ The Starrett Vibrometer. American Machinist., v. 77, no. 17, Aug. 16, 1933. p. 547. (figure) Also Engineering, v. 136, no. 3539, Nov. 10, 1933.

Description of a simple form of the vibrometer, suitable for measuring the amplitude of the vibrations of steam and hydraulic turbines or other high speed, rotating machinery.

______________ Avoiding Instrument Vibration. Scientific American, v. 149, no. 4, Oct. 1933. p. 180. (figures)

Delicate airplane instruments will function correctly only if the amplitude of the instrument panel vibration is less than 4/1000 in. The new Sperry vibrometer consists of a relatively heavy handle (about 5 lbs. in weight) and a precision indicator gage is indicated in 1/1000 in. When measuring the vibration, the instrument is held in the hand and the end of the shaft is lightly pressed against the panel.

Geiger, J. „Anzeigende oder aufschreibende Schwingungsmessgerate. Z.V.D.I., v. 77, no. 5, Feb. 4, 1933. p. 114. (references)

Description of the Universal vibration measuring apparatus.

Koch, H. W. and Zeller, W. Zur Theorie der Schwingungsmesser. Zeit. Instrumentenkunde, v. 53, no. 2, Feb. 1933. p. 64-70. (figures, references)

Solution of the differential equations of the vibrographs for a disturbing function resulting from sinusoidal oscillations with arbitrary phase differences. Influence of self-vibrations of the vibrograph discussed. The effect of phase differences of the coercive forces on the amplitude and phase of the vibration of the vibrograph given.

Koch, H. W. and Zeller, W. Anwendung von Schwingungsmessern im Eisenbahnwesen. Organ für die Fortschritte des Eisenbahnwesens, v. 88, no. 20, Oct. 15, 1933. p. 385-390. (figures, references)

Critical review of the apparatus and methods used in the study of vibrations in railroad tracks, bridges and trains.

Léglise, P. La Technique et la Recherche Scientifiques au XII Salon de l'Aeronautique. L'Aeronautique, v. 15, no. 166, March 1933. p. 55-60. (figures)

The exhibition described, covers the aeronautical research being undertaken under the auspices of the French Air Ministry and was shown at the recent Paris aircraft show. Included in the work is a method of recording the deformations and vibrations of a wing in flight.

Lürenbaum, K. Der D.V.L.-Verdreh-Schreiber. Z.F.M., v. 24, no. 7, April 13, 1933. p. 199-201. (figures, references) Also D.V.L. Jahrbuch 1933. Rep. No. 314. p. V 37-39.

Technical description of an installation for measuring and recording at a distance torque strain on a length of shaft, designed by the D.V.L. Detailed end and side sketches and three photographs given. Record diagrams are scratched by a steel and diamond point on a uniformly moving strip. Calibration is discussed and three diagrams, enlarged 16 times, are reproduced and show torque oscillations in detail. Improvements and applications are suggested.

Raetsch, E. Ein einfaches Verfahren zur photographischen Aufzeichnung von Bewegungsvorgangen. Zeit. Instrumentenkunde, v. 53, no. 6, June 1933. p. 283-285. (figures)

Small vibrations in space or large vibrations in a plane are recorded by fixing one or more transparent screens to the object to be investigated. The screens are provided with a series of reference lines and points which are photographed on a rotating drive through a narrow slit. Numerical values of the displacements are obtained from dimensions of the optical system and separate calibration is unnecessary.

Roensch, M. M. Measurements of Crankshaft Whip and Vibration. Instruments, v. 6, no. 4, April 1933. p. 75-76. (figures)

Description of an apparatus set up for an examination of the deflection occurring at the center of an experimental 6-cylinder crankshaft under operating conditions.

Schrader, J. E. The Tri-Dimensional Vibrograph. Franklin Inst.-Jl., v. 215, no. 4, April 1933. p. 455-469. (figures)

Technical description of apparatus illustrated by photographs and diagrammatic sketches. The instrument records linear acceleration in three rectangular coordinate directions continuously on steadily moving film. Fourteen sections of oscillogram are reproduced and illustrate records with vibrations with components in one only, in two, and in all three directions.

Späth, W. Die Untersuchung von Schwingungserscheinungen durch Phasenmessungen. Electrotechnische Zeit., v. 54, no. 1, Jan. 5, 1933. p. 10-12. (figures, references)

The apparatus described is used for the investigation of the phase relationships of mechanical vibrations such as those produced by ship propellers, out-of-balance rotors or vibration testing machines or recorders.

Späth, W. Schwingungsprüfmaschinen in der Electrotechnik. Electrotechnische Zeit., v. 54, no. 22, June 1, 1933. p. 519-521. (figures, references)

Any system capable of mechanical vibration can have applied to its forces or moments varying sinusoidally and capable of variation in magnitude, frequency, direction and phase by means of eccentrically mounted rotating masses. These masses are rotated synchronously but in opposite directions. The critical frequency, damping and dynamic elasticity are determined from resonance curves obtained from observations of the input to the d.c. motor employed to drive the eccentric masses. Testing machines are described for the investigation of such systems as rotors, foundations, bridges, machine parts, etc.

Stieglitz, A. and Gilbert, E. Die D.V.L.-Drehschwingungs-Anlage. Z.F.M., v. 24, no. 9, May 15, 1933. p. 253-255. (figures)
Also D.V.L. Jahrbuch 1933. Rep. No. 318. p. V 40-42.

Technical description of the installation, with two photographs and four sketches. A 5 kw. d.c. motor drives the installation under test up to 10,000 r.p.m. The installation is suitable for testing damping devices and for fatigue tests of materials.

Tuckerman, L. B., Dryden, H. L. and Brooks, H. B. A Method for Exciting Resonant Vibrations in Mechanical Systems. Bur. of Standards-Jl. of Res., v. 10, no. 5, May 1933. Res. Paper 556. p. 659-660.

Briefly describes the essential features of a method of exciting resonant vibrations in mechanical systems developed for the study of vibrations of aircraft propellers.

Zand, S. J. and Swisher, L. N. Anti-Vibration Mounting of Airplane Instruments. U. S. Air Services, v. 18, no. 6, June 1933. p. 26-31.
Also Aeroplane, v. 47, no. 1221, Oct. 17, 1934. p. 459-460. (figures, equations).

Includes a description of the instrument developed by the Sperry Gyroscope Co. to measure the amplitude of vibration.

______________ Vibration Tester for Instruments. Aero Digest, v. 24, no. 3, March 1934. p. 47.

Description of the Sperry vibration tester, a simple vibrometer to measure the amplitude of vibration in an instrument panel.

______________ Höchstbeschleunigungsmesser. Z.V.D.I., v. 78, no. 27, July 7, 1934. p. 835-836.

A rod, free to move axially, is placed against the vibrating body and transmits the motion to a mass mounted eccentrically on the axis of a flywheel and carrying a sliding electrical contact. A pointer, set on the common axis, is controlled by a spring. An initial tension can be found for which the pointer is not deflected by the vibration and this is a measure of the maximum acceleration of the rod. The maximum acceleration up to 10 m. per sec.$^{-2}$ can be measured.

______________ Research Reveals Nature of Vibrations in Two-Bearing, Four-Cylinder Crankshafts. Automotive Industries, v. 71, no. 8, Aug. 25, 1934. p. 238-239.

Description of the equipment employed in the experimental investigation of transverse vibration of such crankshafts.

______________ Vibration Velocity Indicator. Instruments, v. 7, no. 10, Oct. 1934. p. 217.

Description of a portable, self-contained, novel, electromagnetic device for measuring the velocity of vibration of an object in the noise-producing frequency range. This device requires no tubes, batteries or external power and operates at any angle from horizontal to vertical. An attachment is obtainable whereby the instrument can be permanently mounted and its output used to sound an alarm or shut down machinery when the velocity exceeds a predetermined value, or for recording.

______________ Appareil Delprat et Durand Destine à Mésurer les Oscillations Horizontales des Ouvrages. Revue Génèrale des Chemins de Fer et des Tramways, v. 53, no. 5, Nov. 1934. p. 347-353. (figures)

Description of the Delprat and Durand apparatus for the measurement of horizontal vibrations of structures. Records of vibration of railroad bridges were obtained by means of this instrument.

Caldwell, F. W. Aircraft-Propeller Development and Testing Summarized. S.A.E.-Jl. (Trans.), v. 35, no. 2, Aug. 1934. p. 297-310; no. 3, Sept. p. 349-358. (figures, tables, equations, discussion)

Aug.- Brief discussion of the aerodynamics of aircraft propellers and experiments carried out in the U. S. in the last few years. Included is a discussion of stress analysis and methods of measuring vibration stresses. Determination of the natural periods of vibration by tests. Measurement of vibratory stress in rotating blades by means of "extensiometers". Sept. - Propeller testing for the determination of strength. For the purpose of making accelerated tests of the effect of forced vibration under severe overload. A vibrating machine is described.

Constant, H. Aircraft Vibration. British A.R.C., R. & M. No. 1637, Oct. 1934. 30 p. (appendices, figures, tables)

Appendices discuss vibrographs, modes of vibration of an aircraft fuselage, etc.

Dryden, H. L. and Tuckerman, L. B. Airscrew Vibration Indicator. Bur. of Standards-Jl. of Res., v. 12, no. 5, May 1934. p. 537-542. Res. Paper 678. (figures, reference)

An electro-magnetic indicator was designed for direct record of vibrations of any working combination of engine and airscrew. A diagram shows a record from 20 to 150 cycles per second. The indication in milliamperes is plotted and shows well defined peaks at synchronism, with the fundamental and the first harmonic.

Grey, R. B. Prevention of Vibration and Noise. Inspection, v. 5, no. 1, Jan. 1934. p. 1-24.
Also Mechanical World, v. 94, no. 2447, Nov. 24, 1933. p. 1124-1125; no. 2448, Dec. 1. p. 1148-1149.

Three classes into which vibration can be divided and into which machinery can be divided for the purpose of isolation. How transmission takes place; foundation; properties which resilient material for isolating foundation should possess; springs; isolating sensitive apparatus; anti-vibration devices; vibrograph instruments; harmonic balancing gear.

Heck, N. H. Vibration Meter for Earthquake Studies of Buildings. Engineering News Record, v. 112, no. 10, March 8, 1934. p. 315.

Features of portable instrument developed by the U.S. Coast and Geodetic Survey which is equipped with a photographic recorder.

Labarthe, A. Nouvelles Méthodes de Mésures Mechaniques, Indications des Pressions Moyennes, Torsiographes et Accèlerographes. Soc. des Ingénieurs de l'Automobile-Jl., v. 7, no. 7, Aug.-Sept.-Oct. 1934. p. 2829-2848. (figures)

Author gives the theory and description of devices for the measurement of torsion of transmission shafts under the action of the motor's couple and the couple of resistance. Discusses the regime of resonance and the methods to obtain all critical speeds corresponding to a given frequency. Novel methods of mechanical measurements presented, such as indicators of mean pressures, torsiographs (for automobiles and airplanes) and accelerographs.

Mori, S. Indicator of Torsional Vibrations Constructed by Applying Phenomenon of Magnetostriction. Soc. Mech. Engrs.(Japan)-Jl., v. 37, no. 206, June 1934. p. 343-346. (In Japanese with English abstract, p. S41-42)

The indicator used by the author consists of magnetized nickel rod having a flywheel at one end. To decrease the natural frequency of the indicator. a spiral spring is inserted between the flywheel and rod and coil surrounding the rod is kept stationary. Experimental results are given.

Obata, J., Morita, S. and Yoshida, Y. On the Electrical Method of Measuring Small Vibrations, and Its Application to the Measurement of Vibrations of Airscrew Blades. Aero. Res. Inst., Imp. Univ., Tokyo, Rep. No. 103, v. 8, no. 7, Feb. 1934. p. 256-268. (appendix, figures, tables, references)

Body under examination forms part of a small air condenser, changes in the capacity of which produce change in grid voltage of an amplifying set. The free transverse vibration of an airscrew is examined by clamping the boss rigidly and striking the blades at various points. The frequencies that are obtained are in general agreement with the theory.

Papault, R. Mésure de l'Amplitude et de la Fréquence des Vibrations Existant à Bord des Aeronefs. L'Aeronautique, v. 16, no. 184, Sept. 1934. p. 81. (figure)

A light coil, carrying continuous current, is attached to the vibratory part and the amplitude and frequency of the vibration are determined from the current induced in a fixed coil. An electrical amplifying valve circuit is described with response practically independent of the frequency. An oscillation of 17 mm. amplitude and 15 cycles per sec. frequency produced a current varying between 45 and 110 milliamperes as the mean distance between the coils was varied from 12 to 3 cm.

Sell, H. and Turetschek, G. Quantitative Messung von Erschütterungen. Zeit. Tech. Phys., v. 15, no. 12, Dec. 1934. p. 644-652. (figures, bibliography)

Quantitative measurements of vibrations. Notes on the fundamentals of the measuring system. Inter-relation between motion and speed. Relation between motion, speed and acceleration. Direct indicating vibration measuring instruments. Simplification of conditions. Acceleration measuring instruments.

Theodorsen, T. and Gelalles, A. G. Vibration Response of Airplane Structures. N.A.C.A., Tech. Rep. No. 491, 1934. p. 319-338. (figures, tables, references)

Test results of experiments on vibration-response characteristics of airplane structures on ground and in flight. Also gives details of construction and operation of vibration instruments developed by the N.A.C.A.

Zoellich, H. Aufzeichnung schnell veränderlicher Vorgänge. Arch. für Technisches Messen, v. 4, no. 41, Nov. 30, 1934. p. T141-142; no. 42, Dec. 31. p. T156-158; no. 43, Jan. 1935. p. T5.

Recording of rapidly changing processes. Reproduction of simple and complicated harmonic vibrations developed from laws for forced harmonic vibrations. Fundamental equations. Two-and three-dimensional graphs. Reproduction of non-periodic processes. Examples of some of the processes and methods of their reproduction. Curves. Artificial connections for the decrease of distortion. Correction of distorted curves.

_______________ Torsional Fatigue Tester. Instruments, v. 8, no. 1, Jan. 1935. p. 28.

Description of a new machine which produces torsional vibration in a specimen between two adjustable limits which may be chosen in such manner that the specimen undergoes no permanent deformation until fatigue limit has been reached.

_______________ A Sensitive Vibration Recorder. Scientific Instruments-Jl., v. 12, no. 10, Oct. 1935. p. 327-328. (figures)
Also Engineer, v. 160, no. 4149, July 19, 1935. p. 74.

Detailed description of a sensitive, portable vibration recorder manufactured by C. F. Cassella and Co.

Bernhard, R. Geräusche und Erschütterungen als mechanische Schwingungen infolge Eisenbahn und Strassenverkehr. Bauingenieur, v. 16, no. 15-16, April 12, 1935. p. 176-181; no. 17-18, April 26. p. 206-211. (figures, references)

Description of modern instruments and methods for the measurement of noise and vibrations produced by railroad and street railway traffic, with special reference to the experimental work done by the railroad administration of Germany.

Boydston, R. W. Extending the Range and Usefulness of the Zeleny Electroscope by Automatically and Mechanically Counting Rapid Oscillations. Amer. Phys. Soc.-Proc., Paper No. 61, St. Louis Meeting, Dec. 31, 1935-Jan. 2, 1936.

Difficulties of operation, due to the fact that the leaf sticks to the plate and the inability of the observer to accurately count rapid oscillations, are overcome by the author. Currents ranging from $10^{-12}$ to $10^{-8}$ may be measured; the counting device capable of recording leaf oscillations as high as 125 per sec. A useful and reliable research instrument described.

Gondet, H. and Beaudouin, P. Vibrographe-Accélèrographe Piézo-Electrique. Revue Génèrale de l'Electricité, v. 37, no. 16, April 20, 1935. p. 499-508. (figures, equations, references)

Theory given of the accelerograph and vibrograph made of piezo-electric quartz. Description in detail of a complete apparatus for detection and registration. Some particularly interesting results are shown at the end of the article. A model detector is shown, attached under the wing of an airplane, for determination of vibrations in flight. Diagrams of vibrations of an airplane's wings.

Guerbilsky, M. A. Dynamomètres Piézo-Electriques à Cristaux en Vibration de Résonance. Journées Scientifiques et Techniques de Mécanique des Fluides, v. 1, 1935. p. 43-48. (figures, references)

The author describes a device designed by him and Mr. Riabouchinsky for the experimental study of certain problems pertaining to the airplane's wings, for instance, the strains of the wings in its different parts while in a state of vibration.

Hartel, H. Der Resograf, ein Gerät zur Schwingungsuntersuchen. Werkstattstechnik und Werksleiter, v. 29, no. 11, June 1, 1935. p. 223-224.

Resograph equipment for the study of vibrations. Description of equipment of small dimensions which is relatively light and can easily be adjusted, employing a cathode-ray tube.

Holtschmidt, O. Eine neure Schwingungs-und Dämpfungsprüfmaschine der Man. Mitteilungen aus den Forschungsanstalten. Anst. G.H.H. Konzern, v. 3, no. 10, July 1935. p. 279-284.

Description of the new Man vibration and damping machine with which fatigue resistance can be measured by the Woehler method according to the new process of Esau and Kortum. Damping is determined practically with no loss of time; the machine is electro-magnetically excited. Illustrations given of its use for bending and torsional vibration tests.

Koch, H. W. Schwingungsmessgeräte in Flugzeugen. Zeit. Tech. Phys., v. 16, no. 12, Dec. 1935. p. 603-607.
Also Luftwissen, v. 3, no. 2, Feb. 1936. p. 55-56.
Zeit. Instrumentenkunde, v. 56, no. 6, June 1936. p. 250-252. (figures)

The Wass vibration indicator, for measuring the vibration of an airplane as a whole, is a leaf-spring seismograph with two masses, each consisting of two parts. The normal natural frequencies of the device for measuring 6.5 cycles per sec. can be reduced to two cycles per sec., while the device can be regulated for any desired damping although one between 8:1 and 10:1 is generally used.

Kroon, R. P. Mechanical Tests on Turbine Blades. Instruments, v. 8, no. 6, June 1935. p. 154-155, 159. (figures, bibliography)

The value of tests on simple models of actual blades for the purpose of avoiding blade wrecks. Explanation of how vibrations come about in steam turbine blades. Factors in minimizing failures. Description of an electric blade vibrator developed by J. G. Baker to study blade vibrations experimentally by being able to vibrate them at will. One of the features is to make the blades excite their own vibration at their natural frequency. For tests of mechanical strength the vibrator is used exclusively. Actual experiments described.

Langevin, A. Utilisation du Quartz Piézo-Electrique pour l'Etude des Pressions Variables et des Vibrations à Fréquences Elevées. Revue Générale de l'Electricité, v. 37, no. 1, Jan. 5, 1935. p. 3-10. (figures, equations, references)

The author, after referring to the laws of the piezo-electric phenomena, proceeds with the explanation of the use of a piezo-electric device for the study of various forces. The practical use of this device is described and the given examples of its application show in which way it may be used in the study of vibrations of high frequency.

Meyer, E. and Boehm, W. Ein elektrodynamischer Erschütterungsmesser und seine Anwendung auf die Untersuchung von Gebäudeerschütterungen. Elektrische Nachrichten-Technik, v. 12, no. 12, Dec. 1935. p. 404-414. (figures, references)

Electrodynamic vibration measuring instrument and its application to the study of building vibrations. Description of the apparatus. Constructional details and application. Calibration and results of measurements are shown in curves.

Müller, O. Gerät zum Messen von Schiffschwingungen. Forschung aus dem Gebiete des Ingenieurwesens, v. 6, no. 5, Sept.-Oct. 1935. p. 234-239. (figures, equations, references)

Device for measuring ship vibration. Discussion of mechanical vibration meters and details of a new measuring device and its advantages. The influence of rolling on the measurement of dipping motion considered.

Muller, W. J. Stroboscopic Measurement of Torque and Torsional Vibrations in Ship's Propeller Shafting. Soc. Naval Architects and Marine Engrs.-Trans., v. 43, 1935. p. 241-251. (figures, tables, equations, reference, discussion)
Also Marine Eng'g. and Shipping Rev., v. 41, no. 1, Jan. 1936. p. 33.
Shipbldr. and Marine Engine Bldr., v. 43, no. 316, April 1936. p.?285-287.

Description of a long base system torsionmeter developed in which the difficulties encountered in using the adjusting device employed on the usual long base torsionmeters is eliminated. The expedient of taking measurements at the two ends of the measuring length instead of at one end, thus doing away with the transmitting device from one end to another, has made possible the improvement noted. In addition to describing the device and explaining its use, the author expounds the principles on which the invention was worked out.

Partridge, G. F. The Measurement of Small Amplitudes of Vibration. Phil. Mag., S. 7, v. 20, no. 136, Nov. 1935 Suppl. p. 953-963. (appendix, figures, tables, equations, references)

It is shown that by using a suitable pendulum it is possible, by means of the method Bragg suggests, to measure amplitudes of the order of $10^{-6}$ cm. with an accuracy of a few per cent. As is shown in the appendix, the formula which has been used for calculating the results is, in the case of a quartz vibrator, accurate to within .02 per cent, so that the variations in the results are due to errors in observation. The correction term given in the appendix agrees with the expression developed by Warren for the case of flexible loud-speaker diaphragms, in which case it becomes important. It will appear from the results in the appendix, that the method is not suitable for measurements at resonance.

Soderberg, C. R. Recent Developments in Steam Turbines. Mechanical Engineering, v. 57, no. 3, March 1935. p. 165-173. (figures, table)

Part of the paper describes an electro-magnetic vibration tester in which structures can be tested to destruction under frequencies as high as 20,000 cycles per sec. This tester is useful in working out the requirement of making blades as immune as possible to vibratory stresses. The difficulties in devising a conclusive method of interpretation of test results obtained by this method.

Stitz, W. E. The Development of a Mechanically Operated Frequency Meter and Tensiometer. Part II. A.C.I.C., v. 8, no. 701, Sept. 1935. 16 p. (figures, tables, references)

This is an addition to Air Corps Tech. Rep. No. 3676, and describes a new and improved frequency meter, incorporating as many improvements in design as was suggested by the experience gained with the original experimental instrument. New methods of using the meter for determining the fundamental frequencies of vibration of aircraft structures are also described. The instrument can be used to measure the fundamental frequencies of vibration of wings, ailerons, complete tail surface assemblies, engine mounts and propellers. The methods that have been used to measure frequencies of airplane structures are explained in detail. Recommendations for the design of future instruments.

Trèves, E. Le Beton Vibré. Considerations sur les Différents Modes de Vibration. Génie Civil, v. 107, no. 16, Oct. 19, 1935. p. 366-371. (figures, references)

Comparative study of modern types of concrete vibrators and methods of vibrating used in construction of French and Swiss bridges, buildings, highways, etc.

Zoellich, H. Aufzeichnung schnellerveränderlicher Vorgänge durch langsame Messgeräte. Arch. für Technisches Messen, v. 4, no. 46, April 1935. (V 365-367) p. T48. (bibliography)

Recording of rapidly changing processes by slow-acting measuring instruments. Application of apparatus with excessive damping and apparatus of small natural frequency. Examples.

____________ Vibrators. Electronics, v. 9, no. 2, Feb. 1936. p. 25-29.

Present status of development; initial problems in design. Circuits and illustrations of power vibrators and accessory equipment.

____________ Der D.V.L. Mehrzylinder-Glimmlampen-Indikator für schnellaufende Kolbenmaschinen. L.F.F., v. 13, no. 10, Oct. 12, 1936. p. 357-360. (figures, references)

By means of a practically inertia-free gas-discharge lamp, the D.V.L. glow-lamp indicator records optically the mean time-pressure diagram. Diagrams for as many as 8 cylinders may be simultaneously obtained for a high-speed engine. The indicator has been developed for recording high-pressure and low-pressure diagrams and for remote control of the recording device. In addition, vibration in the fuel, air and exhaust-gaslines can be recorded with this apparatus.

Couch, H. H. Propeller-Crankshaft Vibration Problems. A.C.I.C., v. 8, no. 703, April 15, 1936. 12 p. Air Corps Tech. Rep. No. 4163. (figures)
Also Mechanical Engineering, v. 58, no. 4, April 1936. p. 215-221.

Part II is devoted to a description of several types of pick-ups developed by the Materiel Division to obtain vibration under operating conditions. Description of the method of determining the different types of vibration under running conditions. A few typical oscillograph records showing propeller vibration. Several methods of eliminating severe crankshaft and propeller vibrations are proposed.

Dodds, E. M. Development and Application of the Cathode-Ray Engine Indicator. S.A.E.-Jl. (Trans.), v. 39, no. 6, Dec. 1936. p. 487-495. (figures, bibliography)

Describes a number of applications of the cathode-ray tube to the solution of engine problems, such as indication of pressures in the cylinder and in Diesel fuel lines and mechanical vibration of moving parts. Discusses torsional oscillations of shafts, whip of shafts and time of arrival and duration of flame at any point in the cylinder-head. The different techniques involved when hard, vacuum, cathode-ray tubes are used instead of the gas-filled variety is also indicated. An outline is given of some of the work rendered possible by its aid.

Draper, C. S. The New Instrument Laboratory at M.I.T. Aeronautical Sciences-Jl., v. 3, no. 5, March 1936. p. 151-153. (figures)

Fundamental instrument problems are studied by means of the special apparatus described in order to check the agreement of theoretical predictions with experiment. Among other instruments described is a mechanical vibration apparatus. In order to analyze vibration problems into the simplest possible terms, a machine has been constructed for subjecting instruments to linear simple harmonic vibration. Description of how the effect of vibration in different directions with respect to an instrument mechanism is found.

Draper, C. S. and Bentley, G. P. Measurement of Aircraft Vibration During Flight. Aeronautical Sciences,-Jl., v. 3, no. 4, Feb. 1936. p. 116-121. (figures)

Precision apparatus developed suitable for use in flight for the quantitative study of all types of vibration. Component parts of the instrument and the method of calibration are described. Sample records and test results are presented. Equipment includes pick-up units for both torsional and linear vibrations. The same recording apparatus can be operated by all types of pick-up units. The record is a photographic trace showing the variation of vibration displacement or vibration velocity with time.

Heldt, P. M. Engines on the Spot. Automotive Industries, v. 74, no. 11, March 14, 1936. p. 398-402. (figures)

Engine vibration and cylinder phenomena are explored, making use of the RCA cathode-ray oscillograph and several forms of piezo-electric pick-up devices.

Kallhardt, E. Indizieren schnellaufender Verbrennungskraftmaschinen. Forschungsheft 376, v. 7, Jan.-Feb. 1936. p. 1-12.

Indicating of high speed internal combustion engines. Results of investigation carried out on carburetor engine with three modern indicators, i.e., optical Maihak rod-spring indicator, Fainboro indicator, and piezo-electric indicator. Results show that the piezo-electric indicator gives the most accurate results.

Koch, H. W. and Zeller, W. Schwingungsmessverfahren und ihre Anwendung in der Praxis. Z.V.D.I., v. 80, no. 48, Nov. 28, 1936. p. 1440-1446. (figures, bibliography)

Various vibration measuring methods and equipment. Underlying principles and applications in practice discussed.

Mason, C. A. and Ray, B.B. Piezo-electric Vibration Meter. Electrician, v. 117, no. 10, Nov. 6, 1936. p. 565-567. (appendix, figures, bibliography)

An instrument for detection and quantitative measurement of bearing vibrations. Application to balancing of turbo-rotors, showed the smallest amplitude of an order of 0.0001 in. and vibrations at any frequency up to 70 c.p.s. Valve amplification is found necessary and a carrier-wave system was used. Complete circuit diagram given, as well as a table of general data and curves showing the calibration with various factors. Apparatus was found to be both sensitive and accurate.

Nicolich, A. Nuovi Tipi di Multivibratori a Triodi. Alta Frequenza, v. 5, no. 7, July 1936. p. 430-436. (figures)

Two new arrangements of multi-vibrators derived from known asymmetrical multi-vibrator and giving similar performance. One of the circuits consists of two triodes and has been arranged to need only one coupling whose time constant is such as to avoid complex oscillations. The other circuit employs only one triode.

Pettitt-Herriott, J. Engine Test Equipment. Aircraft Engineering, v. 8, no. 85, March 1936. p. 61-67. (figures)

Device for testing of engines. Description of the instrument and the method of operation used to measure the speed or frequency of a rotating or oscillating part.

Roberts, J. L. and Greentree, C. D. Turbine Supervisory Instruments and Records. A.S.M.E.-Trans., v. 58, FSP 58-7, 1936. p. 607-614. (figures, references)

Description of a set of instruments for the electric measurement and detection of such mechanical quantities as shaft eccentricity, bearing vibration, shell expansion and interference or rubbing of rotating parts. An analysis of typical, as well as special starting-and loading-sequence records taken on a 160,000 kw. steam and a 20,000 kw. mercury vapor turbine generator and conclusions which pertain to the adaptability of the instruments to turbine operation.

Spain, C. J., Loye, D. P. and Templin, E. W. Reduction of Airplane Noise and Vibration. A.S.M.E.-Trans., v. 58, AER 58-5, 1936. p. 423-431. (figures, references)

For passenger comfort it is necessary to reduce noise and vibration in airplanes. The method of doing so is described and is of necessity different from the methods used in automobiles where weight is not an important factor. The measurements resorted to in determining the methods which shall be used in reducing the airplane noises and vibration are also discussed. The article deals principally with noise measurements. Vibration-frequency analyses were made in flight tests. Description of vibrometer used. Various vibration components considered. All components of propeller rotational speed both up to and including the seventh harmonic are prominent almost to the exclusion of all other vibration components. The value of the vibration data obtained from the vibrometer is discussed.

Steen-Johnsen, H. Supervising Instruments for the 165,000 kw. Turbine at the Richmond Station. A.S.M.E.-Trans., v. 58, FSP 58-9, 1936. p. 621-626. (figures, references)

Description of the supervisory-control instruments installed on the 165,000 kw. turbine at the Richmond Station of the Philadelphia Electric Co. The installation consists of electrical instruments to measure such turbine characteristics as vibration, spindle eccentricity, cylinder expansion and noise.

__________ Vibration Pick-Up. Automotive Industries, v. 76, no. 15, April 10, 1937. p. 572-573. (figures)

The article describes the Sunco Model 156 Vibration Pick-Up and Model 150 Neobeam Oscilloscope used to determine the frequency, amplitude and velocity of vibration. The response is said to be practically linear up to the resonant frequency of 2500 cycles per sec. The output sensitivity is relatively high, 2 volts r.m.s., with an amplitude of 0.001 in. at 400 cycles per sec. The lower limit of frequency response is not stated.

__________ Cathode-Ray Oscillograph Use is Investigated. Automotive Industries, v. 76, no. 23, June 5, 1937. p. 853-856. (figures)

Studies of both linear and torsional vibration in engines by means of the cathode-ray oscillograph. A torsional vibration-pick-up device is described.

Bentley, G. P. Aircraft Vibration Flight Testing. Aeronautical Sciences-Jl., v. 4, no. 8, June 1937. p. 316-319. (figures)

The electrical vibration recording instrument developed as part of an M.I.T.-Navy research program permits various components of vibration to be measured in fields of complete engine motion, crankshaft vibration and structural vibration. Description of the recording procedure. Record analysis described; a set of records analyzed and results for purposes of illustration.

Bernhard, R. K. Artificial Vibration, a New Method of Dynamic Research. Civil Engineering, v. 7, no. 4, April 1937. p. 286-287. (figures, table, reference)

Artificial vibration consists essentially of inducing vibrations in the structure to be tested by means of an oscillator attached directly to it, and observing the energy consumed by the oscillator at various frequencies of vibration. All dynamic properties of a structure can be determined by this method. Description of the oscillator. Outline of the steps necessary in carrying out the test. Brief discussion of how to analyze the results. Advantages listed for the new method.

Bleakney, W. M. Compensation of Strain Gages for Vibration and Impact. Bur. of Standards-Jl. of Res., v. 18, no. 6, June 1937. p. 723-729. (figures)

A strain gage (which may be used to record vibratory strains in aircraft during flight) when attached to a vibrating member, undergoes deformations on account of the inertia of its parts, and these may cause serious errors in the strain readings. This paper describes methods for so adjusting the ratio of inertia to rigidity of the parts of the gage that these deformations are compensating. The indication of the instrument may thus be made independent of any acceleration of the gage as a whole.

De Forest, A. V. Measurement of Propeller Stresses in Flight. Aeronautical Sciences-Jl., v. 4, no. 6, April 1937. p. 227-232. (figures, bibliography)

Practical solution of the problem of measuring aircraft propeller stresses in flight. For the study of the airplane propeller, the equipment must be designed to result in giving adequate strength to all parts with a minimum of parasitic weight, in order not to decrease the aerodynamic efficiency of the propeller blade. Ultimately, a pick-up, which fulfilled the desired conditions to a degree which permitted a practical and accurate continuous recording of propeller stresses in flight, at any selected points of the hub and blades, was evolved. Suitable directional accelerometer units and torsional vibration units have been evolved at M.I.T. It is to be expected that a combination of these instruments with dynamic strain measurements of all important parts of the propeller and engine will lead to a much better understanding of the origin of propeller stresses than has heretofore been possible.

Draper, C. S., Bentley, G. P. and Willis, H. H. The M.I.T.-Sperry Apparatus for Measuring Vibration. S.A.E. Preprint of Meeting March 11-12, 1937. 24 p. (figures)
Also Aeronautical Sciences-Jl., v. 4, no. 7, May 1937. p. 281-285.

Automotive Industries, v. 76, no. 12, March 20, 1937. p. 469-470.

Discussion of new equipment which is adapted to record linear and torsional vibration of airplane structures and power plants during actual flight. In its essentials the appartus consists of a number of electrical pick-up units which operate a central amplifying and recording unit. The recorder is a couple-element photographic oscillograph. Each pick-up is adapted especially to the type of vibration that it is intended to measure and is made so small that it does not appreciably affect the vibration characteristics of the member to which it is attached rigidly. By using a number of systematically placed pick-ups, all the necessary vibration information on an airplane can be recorded during a few short flights. The paper takes up in detail flight test installation, sample records and results from flight test, measurement of vibratory strains, pick-up units, strain gage, amplifier, oscillograph and calibrator.

Gravely, C. K. Recording Vibrational Strains in Structural Members. Aero Digest, v. 31, no. 1, July 1937. p. 50.

Description of a practical method of measuring vibrational fluctuating strains in propellers by use of Rochelle salt crystals.

Greentree, C. D. Vibration-Measuring Instruments. Electrical Engineering, v. 56, no. 6, June 1937. p. 706-710. (figures, table, references)

The advantages and disadvantages of certain mechanical and electrical detecting and amplifying systems for the measurement of vibration amplitude, velocity, and acceleration are discussed in the light of their design requirements. A vibration generator capable of producing sinusoidal vibrations over a wide frequency and amplitude range and a set of vibration standards with which the vibrations produced can be accurately determined, are also described. Criteria for evaluating the performance of vibration measuring instruments of different types are suggested.

Lürenbaum, K. Geräte zur Messung der Wellenleistung an Luftfahrzeug-Triebwerken. Z.V.D.I., v. 81, no. 12, March 20, 1937. p. 353-356.

Requirements for taking measurements on an engine shaft during operation and two D.V.L. measuring devices by means of which torque characteristics are recorded on a strip of film in full scale, the shaft itself serving as a measuring spring. With the recording torsiometer, torsional vibration measurements were made on engine drives for motor vehicles, vessels and aircraft under operating conditions. With the other torsion recorder developed for the Junkers aircraft Diesel engine, measurements were successfully carried out at considerable altitudes.

Le Mesurier, L. J. and Stanfield, R. Vibration in Engine Structures. North East Inst. Engrs. and Shipbldrs.- Trans., v. 53, part 5, March 1937. p. 223-246.
Discussion part 6, April 1937. p. D121-130.
Also British Motor Ship, v. 17, no. 206, March 1937. p. 462-463.
Shipbldg. and Shipping Record, v. 49, no. 11, March 18, 1937. p. 332-333.
Mechanical World, v. 101, no. 2632, June 11, 1937. p. 583-584; no. 2634, June 25. p. 634-635, 644; v. 102, no. 2635, July 2. p. 7-8.
Marine News, v. 23, no. 11, April 1937. p. 73-76.
Shipbldr. and Marine Engine Bldr., v. 44, no. 329, April 1937. p. 263-264.
Engineering, v. 143, no. 3716, April 2, 1937. p. 379-380.

Measurement of vibrations and comparison of stresses due to vibrations under running conditions in various parts of engines. Application of the Standard-Sunbury indicator.

Panoff, D. and Riz, P. Appareil pour Enrégistrer les Déformations et les Vibrations de l'Hélice Aérienne pendant le Vol. Inst. de France, Acad. des Sciences, Comptes Rendus, v. 204, no. 7, Feb. 15, 1937. p. 479-481.

In order to study deformations of a propeller and its vibrations during flight, it is necessary to measure directly the relative displacements of various parts of its blades. A recording apparatus was constructed for this purpose according to the authors' plans. With an oscillograph, they obtained the characteristic deformations.

## VIBRATION TREATMENTS - DAMPING AND BALANCING

Burditt, A. K. Static and Dynamic Balancing. American Machinist, v. 66, no. 16, April 21, 1927. p. 643-646. (figures)

The growth in importance of dynamic balancing methods are discussed. The old and present-day methods used in static balancing are noted. Description of how balancing machines are used.

Duncan, D. M. Dynamic Balancing of Rotating Parts. Machinery (Canada), v. 38, no. 3, July 21, 1927. p. 11-13. (figures)

Discussion of the importance of perfect balancing of rotating parts in the elimination of vibration and the explanation of the operation of precision balancing machines.

Hoffmann, D. Statische und Dynamische Auswehtung. Maschinenbau, v. 7, no. 17, Sept. 6, 1928. p. 814-817. (figures)

Description of the Hoffmann-Kunze dynamic method of balancing, also of the "Universal", "punga" and other balancing machines. Vibration measuring instruments are described.

Ormondroyd, J. and Den Hartog, J. P. The Theory of the Dynamic Vibration Absorber. A.S.M.E.-Trans., v. 50, APM 50-7, 1928. p. 9-22. (figures, equations, references, discussion)

The vibration absorber consists of a small vibratory system tuned to the operating frequency of a larger machine and attached to it in a suitable location. When properly designed, this will reduce materially the vibrations of the machine itself. The absorber, without damping, annihilates vibrations of its own frequency completely, but creates two other critical speeds in the machine system. Therefore, it is suitable only for applications on constant-speed machinery. When damping is introduced into the absorber, it constitutes a simple and efficient means of diminishing the vibrations of a machine of variable speed. An analysis of its operation in simple cases, with and without damping, is given. Several of the experimental tests made on a model are described, and actual applications discussed. Detailed analysis of vibrating system of two degrees of freedom.

Kimball, A. L. Vibration Damping, Including the Case of Solid Friction. A.S.M.E.-Trans., v. 51, APM 51-21, 1929. p. 227-236. (figures, tables, references, discussion)

The idea of logarithmic vibration decrement is briefly reviewed and several ways of expressing it and finding it are given. Simple case of a vibrating reed is treated, three kinds of damping being considered. These cases are discussed, both for free vibrations and sustained vibrations. The method is given for analyzing solid damping vibration problems, which is of general application to all cases of vibration that can be treated on the assumption of an ideal viscosity damping. The discussion of vibration damping given herewith, presents methods used by the writer for several years past in vibration work.

Den Hartog, J. P. Forced Vibrations with Combined Viscous and Coulomb Damping. Phil. Mag., S. 7, v. 9, no. 59, May 1930 Suppl. p. 801-817.

The differential equations of forced vibrations with viscous damping, with solid friction damping and with combined damping, are written down and solved. Their validity is discussed and a large variety of numerical relations is given graphically for varying conditions. The method and results should be of interest to structural and engine designers.

Den Hartog, J. P. Forced Vibrations with Combined Viscous and Coulomb Damping. Third Inter. Cong. Appl. Mech.-Proc., v. 3, Aug. 1930. p. 181-189. (figures, references, discussion)

Equations are given for the motion of a system of one degree of freedom on which a harmonic disturbing force is acting and which is affected by a combination of viscous damping and dry friction. Mathematical discussion of pure Coulomb damping and of combined viscous and Coulomb damping. Amplitudes of the steady state vibration of a single degree of freedom subjected to a combination of viscous damping and Coulomb-friction have been calculated. Experiments carried out on a torsional model constructed for the investigation of friction dampers as described in the paper by J. Ormondroyd. Recording done optically in the form of Lissajous' figures. Quantitative measurements with this apparatus show fair agreement with the theory.

Föppl, O. Abhängigkeit der Schwingungsdauer einer gedampften Schwingung von der Grösse der Dämpfung. Z.A.M.M., v. 10, no. 1, Feb. 1930. p. 92-93. (figure)

Analysis of a process of vibration, with and without damping. Concludes that periodical vibration depends on the amount of damping.

Jacobsen, L. S. Steady Forced Vibration as Influenced by Damping. A.S.M.E.-Trans., v. 52, APM 52-15, 1930. p. 169-181. (figures, table, references, discussion)

Presents a general method of obtaining approximate solutions of a steady forced vibration of a damped system of one degree of freedom for the case of sinusoidally varying disturbing forces. The approximation consists in expressing all the damping terms of the original differential equation of a single equivalent damping term, proportional to the power of the velocity of motion. In the case of a system influenced by a centrifugal disturbing force and damped by constant friction and by friction proportional to the first power of the velocity, experimental evidence is in good agreement with the approximate solution.

Kimball, A.L. Analysis of Vibration with Solid Friction Damping. Third Inter. Cong. Appl. Mech.-Proc., v. 3, Aug. 1930. p. 190-198. (discussion, bibliography)

Demonstration of how the amplitude-frequency relation for sustained vibrations of systems containing solid friction damping can be found for any case which can be solved for viscous damping. The energy formula for logarithmic decrement $\delta$ in work on vibration damping and vibration prevention is set forth. Applications to engineering given.

Kimball, A. L. The Damping Factor in Vibrations. Product Engineering, v. 1, no. 11, Nov. 1930. p. 499-501. (figures)

Development of formula for the calculation of logarithmic decrement in measuring the amount of damping present in a vibrating system.

Ormondroyd, J. Friction Dampers and Their Application to Engines. Third Inter. Cong. Appl. Mech.-Proc., v. 3, Aug. 1930. p. 221-233. (figures, equations, bibliography)

A good design theory of forced vibration with Coulomb damping worked out, based on the energy method. Defects of use of energy theory. Model tests and actual engine tests indicate that the deduction of the theory developed by the energy method leads to an accurate method for the design of friction dampers with Coulomb damping. The friction damper can be made more effective by driving it by elastic connections to the engine shaft. The theory of friction dampers with spring drives has been discussed. No actual tests have been made to check this theory.

Thomas, S. Vibration Damped by Solid Friction. Phil. Mag., S. 7, v. 9, no. 57, March 1930. p. 329-345. (figures, equations, references)

The elementary differential equations of solid friction damping and of combined solid and fluid friction damping are formed and solved. Examples are worked out and compared with experimental results, by which the conclusions are generally supported. The method will find applications in the damping of torsional vibrations.

_______________ The Hoffman-Kunze Dynamic Balancing Machine. Automobile Engineer, v. 21, no. 288, Dec. 1931. p. 590-591. (figures)

Design and operating principles of the Hoffman-Kunze balancing machine. Amplitude of vibration is inscribed by pointers on charts in front of machine.

Baker, J. G. and Den Hartog, J. P. Torsional-Vibration Dampers. S.A.E.-Jl., v. 28, no. 2, Feb. 1931. p. 184-190. (figures, references)

Fundamentals of torsional vibration and stress-limiting devices. Tests made on model in laboratory of Westinghouse Electric and Mfg. Co. prove the methods of stress calculation to be reliable.

Davey, P. Unusual Balancing Problems; Vibration Problems. Machinery (N.Y.), v. 37, no. 5, Jan. 1931. p. 325-328. (figures)
Also Iron Age, v. 127, no. 6, Feb. 5, 1931. p. 452-455.

Description of the performance of the Davey balancing equipment (described, Iron Age, Feb. 28, 1929. p. 610). The equipment utilizes the stroboscopic principle both in the case of rotary and vibratory motions, and ascertains the relations of these motions to each other. The machine and vibrometer, which it includes, is described.

Den Hartog, J. P. Forced Vibrations with Combined Coulomb and Viscous Friction. A.S.M.E.-Trans., v. 53, APM 53-9, 1931. p. 107-115. (appendices, figures, equations, references)

Steady-state vibrations of mechanical systems damped by a combination of dry and viscous friction occur quite frequently, but until recently no method for their calculation existed. A very satisfactory approximation was presented by L. S. Jacobsen before the A.S.M.E. in June 1930. In the present paper, the author gives the exact solution of the problem, together with a number of test results.

Föppl, O. Resonanzschwingungsdämpfer. Ingenieur Arch., v. 2, no. 3, Sept. 1931. p. 347-352. (figures, table, references)

Theoretical analysis of a resonance vibration damper. Experimental verification of the theory.

Ormondroyd, J. Reducing Torsional Vibration by Damping Devices. Machine Design, v. 3, no. 7, July 1931. p. 33-36. (figures)

Several devices for the purpose of eliminating torsional vibration including the Lanchester damper, are considered.

Shaw, H. Experiences with Vibration. American Machinist, v. 75, no. 19, Nov. 5, 1931. p. 693.

Experiences with various kinds of vibrations. Conclusions: (1) that vibration in large surfaces can be reduced in period by breaking the surface up by ribs or holes, (2) unbalancing of a part; (3) loosening of bolts.

Skilling, H. H. Electric Analog of Friction. A.I.E.E.-Trans., v. 50, no. 3, Sept. 1931. p. 1155-1158. (figures, table)

Demonstration of application of the analog of Coulomb friction to the previously unsolved problem of the torsional vibration damper.

______________ The Vickers Damper. Engineer, v. 154, no. 4001, Sept. 16, 1932. p. 286-287. (figures)
Also Engineering, v. 134, no. 3486, Nov. 4, 1932. p. 530-531.

Photograph and sketches of section and side elevation illustrate brief technical account of principles and design of the Vickers damper. Torsiograph diagrams show three undamped vibrations and one damped with notable reduction of amplitude.

______________ Damping Apparatus for Torsional Oscillations. Engineering, v. 134, no. 3486, Nov. 4, 1932. p. 530-531. (figures, references)

Description of the Vickers Sandner damper for torsional vibrations. This is of the flywheel type and is claimed to be reliable and effective on large oil-engine installations. The damper is based on the principle that the flywheel must be detached from the shaft before the amplitude of its torsional oscillations at a critical speed has reached the danger point, this detachment setting up a different natural frequency in the shafting system with a resultant neutralization of the effects of the critical speed.

Adams, A. H. How to Smother Vibration. Power, v. 75, no. 6, Feb. 9, 1932. p. 200-203.

Practical review together with illustrated example of hums, squeals, rumbles, rattles and blows. Method of damping suggested.

Bankwitz, E. Die Abhängigkeit der Werkstoffdämpfung von der Grosse und Geschwingkeit der Formanderung. Mitteilungen des Wohler-Inst., No. 11, N.E.M. Verlag, Berlin, 1932. 53 p. (figures, tables)

A contribution to our knowledge of the behavior of metals under repeated stress. Vibration diagrams of steel, copper, brass and aluminum, based upon careful tests, are given and the influence of speed of deformation upon the magnitude of damping, and of alternating stresses upon the static properties of these materials are discussed.

Bock, G. Schwingungsdämpfung unter Ausnutzung der Werkstoffdämpfung. Z.A.M.M., v. 12, no. 5, Oct. 1932. p. 261-274. (figures, equations, references)

Discussion of the damping of oscillations by internal friction. The hysteresis loop is replaced by an ellipse of the same area and approximately the same maximum and minimum diameters. This substitution renders the differential equations of motion soluble in elementary functions, neglecting the variation in the loop with varying amplitude. Examples are worked out on these lines and resonance curves plotted with and without damping.

Eisenhour, B. E. and Tyzzer, F. G. Elastic Properties of Various Materials and Their Effect on the Transmission of Vibrations. Franklin Inst.-Jl., v. 214, no. 6, Dec. 1932. p. 691-707. (figures, table, equations, references)

Elementary equations are formed for the forced vibration of a simple elastic system with and without damping. Sketch shows simple apparatus for measuring the elastic properties of various materials in the form of pads for reducing the mechanical transmission of vibrations. Numerical tables given.

Fletcher, C. N. Developments in the Balancing of Machinery. Mechanical World, v. 92, no. 2377, July 22, 1932. p. 84-86. (figures)

Description of a new balancing machine wherein the compensating device is entirely automatic. Selected plane method of correction used. Rotating work permitted to vibrate with unusual freedom, being only constrained to vibrate about a point. Under the proper operating conditions, using a well-made balancing head, reduction of the amplitude of the cradle vibration to within 1/1000" is found possible. Claim is made that with an electric rotor weighing 34 lbs., carrying a balancing head weighing 14 oz., an accuracy of less than 0.016 oz. is obtainable. Damping devices may be introduced where the readings of the machine are closer than the limits commercially required.

Föppl, O. Theorie des Resonanzschwingungsdämpfers. Z.A.M.M., v. 12, no. 5, Oct. 1932. p. 257-260. (figures, equations, references)

Elementary example is constructed, in which the damping term is linear and the solution is obtained in the usual way.

Thearle, E. L. A New Type of Dynamic-Balancing Machine. A.S.M.E.-Trans., v. 54, APM 54-12, 1932. p. 131-141. (figures, equations, references, discussion)

Novel type of dynamic-balancing machine developed for production balancing described. Machine employs an automatic compensating device, making it possible for an unskilled operator to obtain accurate readings of the amount and position of unbalance correction with great rapidity. Theory underlying the action of the machine is given and the characteristics of the automatic balancing head are investigated. The method of operating the machine is explained and data on the accuracy of balance obtainable are included.

Hahnkamm, E. Die Dämpfung von Fundamentschwingungen bei Veränderlicher Erregerfrequenz. Ingenieur Arch., v. 4, no. 2, April 1933. p. 192-201. (figures)

For damping of disturbing vibrations additional masses may be used which are coupled with the principal system. Two cases are considered. At a frequency of excitation which is constant or variable between small limits, the main system must be connected with the additional mass by a force coupling. If the exciter frequency can accept all possible values, a friction coupling must be inserted between the main system and the damping mass. In both cases, a most favorable value for the coupling force and for the frequency of the additional mass can be obtained while there exists no optimal value of the damping mass. Latter acts more favorably, the greater it is.

Jendrassik, G. Theorie des Reibungs-Schwingungsdämpfers. Z.V.D.I., v. 77, no. 37, Sept. 16, 1933. p. 1009-1012. (figures, equations)

Elementary dynamic principles of a friction vibration damper discussed and rules for design given. With properly dimensioned parts, adequate damping is maintained over a wide range of variation in the coefficient of friction.

Van Steewen, O. P. Measuring Vibration and Eliminating It. American Machinist, v. 76, no. 11, March 17, 1932. p. 353-355. (figures)

Individual problem of vibration often solved by application and adaptation of uniform principles. Through correct balancing and matching of revolving speeds, avoidance of vibration is aimed at, in construction and assembly. Importance of defining magnitude, direction and frequency of vibrations as preliminary to application of remedial measures. Correction often attained by following simple measures: (1) revolving speed changed; (2) ratio changed; (3) addition of flexible couplings. In forced vibrations, exciting force has first to be removed. At lowest possible reduction, whole unit is made as rigid as possible or by addition of mass, further reduction may be obtained.

Fischer, J. Einige Eigenschaften einfacher elektrischer und mechanischer Schwingungssysteme und ihre Kennzeichnung. Arch. für Elektrotechnik, v. 28, no. 12, Dec. 12, 1934. p. 774-783. (equations, references)

Properties of simple electric and mechanical oscillating systems and their identification. For some linear, electric and mechanical vibrating systems of same inertia, definitions are found for damping and the damping factor. Principal properties of stationary, sinusoidal vibrations are studied with special reference to various resonance properties related to defined characteristics of damping. Measurements of vibrations.

Geislinger, L. Theorie des Resonanzschwingungsdämpfers. Ingenieur Arch., v. 5, no. 2, April 1934. p. 146-155. (figures, equations, references)

Theory of resonance vibration damper discussed. The mass of a vibration damper working on the resonance principle need only be 2% of the mass of the damped system or less, if the timing is accurate. The mathematical investigation shows that bad tuning of the damper is less harmful in defect than in excess of the natural period of the damped system.

Klein, W. Die Messung der Baustoffdämpfung durch Aufnahme der Resonanzkurve. Ingenieur Arch., v. 5, no. 1, Feb. 1934. p. 1-6. (figures, tables, references)

Sketch shows a cylindrical iron bar, on which an electro-magnetic device imposes longitudinal vibrations. Vibrations of the free end observed electro-magnetically by variation of voltage in an induction coil, measured by a valve volt-meter. Elastic equations in polar coordinates and the numerical solution plotted graphically.

Thearle, E. L. Dynamic Balancing of Rotating Machinery in the Field. A.S.M.E.-Trans., v. 56, APM 56-19, 1934. p. 745-753. (figures, equations)
Discussion A.S.M.E.-Trans., v. 57, 1935. p. 140.

Paper describes a means of dealing with that component of vibration which occurs at running-speed frequency, caused by mass unbalance in the rotating member. The system and equipment described will not only simplify the elimination of vibration at running-speed frequency, but will aid in the analysis to determine the causes of vibration at other frequencies. Balancing machines described.

Meissner, E. Resonanz bei konstanter Dämpfung. Z.A.M.M., v. 15, no. 1-2, Feb. 1935. p. 62-70. (figures, equations)

Graphical method to obtain the action of an oscillating system under the influence of a periodical disturbance, with various amounts of friction. Solutions obtained for three cases and general motion described.

Uematu, T. Damped Vibrations of Curved Rods and Thin Plates. Soc. Mech. Engrs. (Japan)-Trans., v. 1, no. 3, Aug. 1935. p. 170-172. (In Japanese)

Investigation of damped vibration of curved rods taking account of viscous resistance. Examples given explaining the damped vibration of thin plates, fundamental equations of which were suggested by K. Sezawa.

Baker, J. G. and Mikina, S. J. The Calculation of Dampers for Systems Subject to Self-Induced Vibrations. A.S.M.E.-Trans., v. 58, Appl. Mech., 1936. p. A121-A126. (appendix, figures, references)

Complete elimination of self-induced vibration cannot be treated generally because the systems in which it occurs (wing flutter is an example) and the conditions under which the systems are subject to this type of vibration, are so varied. however, such vibration can be reduced by damping, and the means employed can be discussed in terms applicable to the whole class of self-induced vibrations. The author shows that the time-displacement curve for the building up of a self-induced vibration is a convenient basis for calculating the amount of damping required to vibration from building up.

Bock, H. Vibrationen bei Gleitreibung. Zeit. Instrumentenkunde, v. 56, no. 2, Feb. 1936. p. 71-74. (figures, equations)

Effect of solid and fluid frictions on the frequency of a mass under spring control undergoing continuous translation investigated. Interesting examples in practice show the heavy damping brought about by fluid friction.

Fuchs, H. O. Spiral Diagrams to Solve Vibration Damping Problems. Product Engineering, v. 7, no. 8, Aug. 1936. p. 294-296. (figures)

Method to analyze the effects of any kind of damping force, such as is exerted by automobile shock absorbers, landing gears, dashpots, electric dampers, rubber mounting and similar devices.

Sablove, S. D. Vibration Damping Tests for Resilient Mountings. Product Engineering, v. 7, no. 7, July 1936. p. 246-248. (figures)

Equations for critical speeds with elastic suspensions and vibrograph method for measuring and recording vibrations in three directions simultaneously. Article is based on thesis study sponsored by the Firestone Tire and Rubber Co. at Drexel Institute.

Smith, P. H. Rubber Takes the Shocks of Industry. Scientific American, v. 154, no. 1, Jan. 1936. p. 22-25. (figures)

Discussion of rubber and its use, present and potential, in various industries. Stress laid on the application of rubber as a vibration damper.

VIBRATION STUDIES IN ALLIED FIELDS - AUTOMOBILES.

Fergusson, D. The Importance of Freedom from Vibration in Passenger Car Engines. Rochester Engineer, v. 4, no. 6, Dec. 1925. p. 124-126. (figures)

Discusses vibrations in 6- and 8-cylinder engines and research to eliminate vibration.

Lehr, E. Balancing of Automobile Crankshafts. Werkstattstechnik, v. 19, no. 24, Dec. 15, 1925. p. 861-865. (figures)

Discussion of the increase in balancing due to increase in spin, torsional and bending vibrations, and critical vibrations. Description of a process of balancing.

Summers, C. E. Measurement of Engine Vibration Phenomena. S.A.E.-Jl. (Trans.), v. 16, no. 2, Feb. 1925. p. 163-171. (figures)
Discussion v. 16, no. 6, June 1925. p. 639-644.

A number of indicating and recording instruments described for recording the actual resultant vibration and for determining its exact character. Vibration due to unbalance of rotating parts, piston unbalance inherent in 4-cylinder engines, bending of the crankshaft, centrifugal force and torsional periods are discussed. Indicator diagrams of various kinds of vibration are shown. Mathematical and experimental analysis.

Heldt, P. M. Torsional Vibration of Crankshafts. Automotive Industries, v. 54, no. 23, June 10, 1926. p. 957-965. (figures)

It is pointed out that lower harmonics of gas-pressure and not inertia forces are principal factors in torsional vibration of crankshafts.

Marquard, E. Grundlagen zur Ermittlung der dynamischen Beanspruchung von Kraftfahrzeugen bei Stössen. Motorwagen, v. 29, no. 30, Oct. 31, 1926. p. 737-742; no. 32, Nov. 20. p. 793-798. (figures, equations, references)

Fundamentals in determination of dynamic stress of automobiles under shock. Experimental determination of axial and framework vibration diagrams. It is shown how such diagrams, for a given case, can be graphically built up, based on purely theoretical principles.

Plünzke, J. Drehschwingungen des Automobilmotors. Motorwagen, v. 29, no. 6, Feb. 27, 1926. p. 115-128. (figures, references)

Complete treatment of torsional vibrations of crankshafts, drawing upon a large amount of research and literature. Application of theories and methods developed by other investigators to three cases of specific interest to automotive engineers; crankshafts of 4-, 6- and 8-cylinder engines. Demonstration by actual examples of how vibration period of such shafts can be calculated.

Slauson, H. W. Comfort from Your Motor. Scientific American, v. 134, no. 1, Jan. 1926. p. 14-15. (figures)

Discussion of vibrations in an automobile gasoline engine due to lack of balance. Problems of balance, rigidity of the crankshaft, damping and friction discussed briefly.

Donkin, W. T. and Clark, H. H. Notes on Valve-Spring Surge. S.A.E.-Jl. (Trans.), v. 20, no. 6, June 1927. p. 722-726. (figure, table)
Discussion v. 21, no. 3, Sept. 1927. p. 243-244.

A study of the influence of vibration on valve-springs reveals the two possible ways in which a valve-spring can vibrate. Analysis of surge effected with the aid of a super-speed motion-picture film and the vibroscope which was used in conjunction with a valve-gear testing machine. Cause of valve-spring failure.

______________ Isolating Engine Vibration. Autocar, v. 60, no. 1683, Feb. 1928. p. 203-204. (figures)

Discussion of the methods used by various manufacturers to reduce engine vibration. Description of flexible mountings used by Alvis Co. and 14 hp. Hillman car. On each side of Rolls Royce engine a damper, of frictional shock-absorber type, absorbs the reaction from torsional vibration in crankshaft. Engine mounting of the 6-cylinder Rover car described. Laminated spring of transverse type used on 4-cylinder Chrysler engine. 14 hp. Humber system.

Baker, M. W. Marmon Adopts "High Frequency Oscillating Modulator". Automotive Industries, v. 59, no. 17, Oct. 27, 1928. p. 596-597. (figures)

New form of torsional vibration damper called "high-frequency oscillating modulator". Description and theory of the device. Experimental work done at the Marmon factory. A special device to prove the existence of numerous periods, vibration exploring mechanism (essentially a triple-tuning fork).

Griswold, W. R. and Moorhouse, A. Designing the Dual Valve-Spring. S.A.E.-Jl., v. 23, no. 5, Nov. 1928. p. 461-469. (figures)

Development of the Packard dual valve springs by rational analysis combined with experimental verification discussed. Analysis of dynamics of valve mechanism. Theory of vibration; previous theories inadequate. Harmonic analysis. Wave theory. Conditions of resonance. Mathematical design of spring.

Huebotter, H. A. Vibration in Automobile Engines. S.A.E.-Jl. (Trans.), v. 23, no. 1, July 1928. p. 107-111. (figures, table, equations, references, bibliography, discussion)

Analytical methods for determining the unbalance inertia force and the tangential effort in a line engine presented. These methods are thought to be of interest for investigation of the effects of various engine design features on its vibration characteristics. An equation for the resultant reciprocating force is set forth and methods of expressing the inertia and fluid-pressure torque are given. The determination of minimum and maximum resultants and the balance of inertia and fluid-pressure torques are other topics dealt with. The results of a series of analyses are incorporated in tabular form.

Boelter, L. Engine Vibration Explained. S.A.E. Meeting Paper (California), Sept. 12, 1929.

Address on engine vibration explains the elementary and fundamental facts. Mechanical formulae given that measure vibration in engines having 1, 4, 6, and 8 cylinders. Difference in vibration between 8 cylinder engines of various forms discussed. Also discusses vertical vibration resulting from periodic unbalance of reciprocating parts, torsional vibration and vibration due to torque reaction.

Fitzsimmons, J. T. Ignition Requirements for High-Compression Engines. S.A.E.-Jl. (Trans.), v. 24, no. 3, March 1929. p. 306-314. (figures, discussion)

Exactions imposed on distributor by engine torsional vibration. Need of automatic spark-advance mechanism in distributor. Peculiar conditions in some engines caused by non-homogeneous mixture surrounding spark plugs. Difficulties arising from shrinkage of materials. Influence of high-compression engine on design of distributor-cam and circuit-breaker lever. Oscillograph studies of circuit-breaker action.

Heldt, P. M. Controlling Torsional Vibration of Crankshaft Assemblies by Dampers and Modifiers. Automotive Industries, v. 60, no. 18, May 4, 1929. p. 684-687, 701. (figures)

Factors influencing torsional vibrations of crankshafts are discussed. Modification is possible by changing distribution of weight along crankshaft, but increasing engine speeds require addition of dampers. Description of Chrysler full-range vibration damper by T. J. Litle, Marmon Automobile Co. Harmonic balancer used on a number of General Motors cars.

Heldt, P. M. Schwingungsdämpfer zum Vermeiden von Torsionsschwingungen an Kurbelwellen. Autom. Tech. Zeit., v. 32, no. 25, Sept. 10, 1929. p. 554-555.

The Chrysler vibration damper acts by friction between two fly-wheels under constant pressure applied by a spring, with a variable pressure depending on the speed superposed by a stressed rubber band; the combination producing effective damping and a wide speed range.

Huebotter, H. A. Engine Torque Analysis. S.A.E.-Jl. (Trans.), v. 25, no. 6, Dec. 1929. p. 641-655. (figures)

Analytical methods of investigating engine torque. Discusses crankshaft vibration; the relation of fly-wheel oscillation to torque curve. Mathematical analysis.

Litle,Jr., T. J. Methods of Obtaining Greater Power from a Given Engine. S.A.E.-Jl. (Trans.), v. 24, no. 1, Jan. 1929. p. 36-40. (figure)

Includes discussion of a new vibration damper for cars that will reduce all the torsional vibration periods in the crankshaft. Suggests that more attention be paid to balancing as large part of offensive vibration is due to lack of balance in the reciprocating and rotating parts.

Wood, K. D. Counterbalanced Connecting-Rods in a Four-Cylinder Engine. Sibley Jl. of Engineering, v. 43, no. 2, Feb. 1929. p. 40-44, 65-66. (figures, tables)

Experimental work carried out for study of the inertia forces on the pistons and rods of a 4-cylinder engine. Principal comclusion is that most of the vibration in a 4-cylinder engine can be eliminated by use of counterbalanced connecting-rods. Vibrograph records were made at varied speeds. Details of experiments given.

________________ Vibration Damper Design. Automotive Industries, v. 62, no. 11, March 15, 1930. p. 434.

Design of vibration dampers found on front end of the Dodge eight crankshaft.

Abbott, F. D. Evaluation Tests for Rubber Vibration Insulators. S.A.E.-Jl. (Trans.), v. 27, no. 5, Nov. 1930. p. 600-604. (figures, tables)

Use of rubber parts in automobiles and airplanes to prevent transmission of engine vibrations and noise by absorbing completely, or changing into unobjectionable forms, all manners of vibration. A complete laboratory analysis of the possible service life of a rubber part is necessary. Series of tests outlined.

Broulhiet, G. Problème du Silence des Engrenages. Soc. des Ingénieurs de l'Automobile-Jl., v. 4, no. 5, May 1930. p. 1010-1023. (figures)

In seeking a generalized and scientific basis for attacking the subject of gear noises and their prevention, the author resorts to the mathematical treatment of vibrations developed by Helmholz between 1860 and 1870. He points out that automotive sounds and noises are only the audible manifestations of vibrations set up in parts which act either as oscillators or resonators. Periodic forces setting up these vibrations have their origin in the lack of balance in rotating parts, etc. After examining subject of vibrations in general, the author considers criteria for judging what vibrations produce disagreeable sounds. In the third section, he applies the theory developed to practical questions of gear design and material. Gear material influences not only wear and hence vibration, but also gear efficiency.

Davidson, M. W. Linear Inertia Force of Connecting Rod Resolved into Two Components. Automotive Industries, v. 63, no. 14, Oct. 4, 1930. p. 479-481. (figures)

Dynamic effect of inertia of connecting rod on bearing and guide pressures, crank and frame torques, and on vibration in reciprocating machinery.

Fromm, H. Schwingungsvorgänge an der Lenkung von Kraftfahrzeugen. Third Inter. Cong. Appl. Mech.-Proc., v. 3, Aug. 1930. p. 278-288. (figures, references, discussion)

Theoretical and experimental treatment of automobile shimmy and similar phenomenon.

Panetti, M. Notizie Generali sulle Oscillazioni dei Veicoli. Third Inter. Cong. Appl. Mech.-Proc., v. 3, Aug. 1930. p. 16-27. (figures, equations)

Review of the existing literature on vibration in side-rod electric locomotives and automobiles. Mathematical relationships of various kinds of vibration and examples given.

Smith, E. H. Elimination of Chassis Vibration. S.A.E.-Jl. (Trans.), v. 26, no. 2, Feb. 1930. p. 156-158. (figures)

Method outlined of mounting the engine so as to reduce the transmission of vibration from it to the frame. A device by which the vibrations in the engine frame could be measured electrically was perfected, and with the engine mounted directly on the frame, three times as much vibration was found in the frame as in the engine. Rubber mounting reduced frame vibration to 1/6 of its original value, with the vibration in the engine remaining the same.

_______________ Borg und Beck-Kupplung mit neurem Schwingungsdämpfer. Autom. Tech. Zeit., v. 34, no. 2, Jan. 20, 1931. p. 32. (figures)

Description of the Borg and Beck coupling with a new oscillation damper. The coupling keeps the rubber cushion drive always under compression which gives increased life to the material.

Andreau, - Etude Experimentale et Theoretique sur les Vitesses Critiques de Vilebrequins de Moteurs. Soc. des Ingénieurs de l'Automobile-Jl., v. 4, no. 9, Nov. 1931. p. 1530-1558. (figures)

Experimental and theoretical study of critical speed of engine crankshafts. Derivation of principal formulae with numerical examples. Data on crankshafts of Mercedes, Maybach, Fiat and Ford engines.

Dirr, A. Das Flattern der Vorderräder und seine Bekämpfung. Autom. Tech. Zeit., v. 34, no. 15, May 31, 1931. p. 351-354. (figures)

Various causes of front-wheel oscillations and method of control by changing camber, caster, etc. Use of shock absorbers and other spring-damping devices. Emphasis on vertical and horizontal motions of the axis.

Hadley, N. F., Lee, R. K. and Janeway, R. N. Engine Mounting to Eliminate the Transmission of Vibration. S.A.E. Meeting Paper, 1931.

Any body which goes through cycles of movement is governed by the same laws as are rotating or reciprocating bodies. This is important in establishing a correct concept of the vibration phenomena which are prevented from reaching the frame and body by the mounting described. Established a mathematical basis for the development and demonstrated points by graphs, charts and suitable apparatus. Applied these fundamentals to engine mountings and gave specific examples of the applications of the facts.

Haushalter, F. L. Isolating Vibrations with Rubber. Product Engineering, v. 2, no. 12, Dec. 1931. p. 542-545. (figures)

Author states that isolation of vibration, vibration damping, noise reduction and shock absorption through the medium of rubber, have been brought forcibly to the attention of engineers recently by notable developments. Motor suspension on rubber mountings and insulation of motor from chassis by rubber pads or bushings have this year become standard construction on many passenger automobiles, due to advances in science of rubber compounding. Methods described. Advantages of use of rubber in this connection are analyzed.

Puls, E. F. Der Puls-Umformer. Autom. Tech. Zeit., v. 34, no. 10, April 10, 1931. p. 229-230. (figures)

Design and operating principles of a device for eliminating the harmful effect of torsional vibration in the transmission system of motor vehicles. This device is mounted between the transmission and propeller shaft and reduces non-uniformity of impulses originating either in the power plant or at the rear wheels.

Wedemeyer, E. A. Beurteilung von Kurbelwellenbrüchen. Autom. Tech. Zeit., v. 34, no. 20-21, July 20, 1931. p. 472-473. (figures)

Interpretation of various causes of crankshaft failures (due to torsional vibrations) in automobile engines, illustrated by examples. Notch effect and concentration of stresses due to improper design, misalignment of bearings, flaw in materials, etc.

__________ A Simple Vibration Damper. Automobile Engineer, v. 22, no. 290, Feb. 1932. p. 76. (figure)

A patented device consisting of a rubber flywheel mounting. Outer portion of flywheel is flexibly attached to the central flange that bolts to the flywheel. Flexible connection between the two is provided by a series of bolts that carry sleeves on the outside of which are mounted rubber rings that fit into the holes in the outer portion of the flywheel. Outer flywheel member is therefore carried elastically on the inner flange, and is located sideways by laminated spring washers under the units. There is no solid connection between the two flywheel parts, and the outer member will obviously have a small measure of movement by virtue of compression of the rings that will take place under the inertia effect.

________ Engine Vibration Damper. Automobile Engineer, v. 22, no. 298, Oct. 1932. p. 451-452. (figure)

Vibration damper, or tie, is mounted on the cylinder head. A flat strip of metal is attached to the head by a bolt at each end, carrying two short upright cylindrical bosses. Encircling these bosses is a band made up of two pieces of stout fabric united by a coil tension spring. Other ends of the fabric are attached to a small strip of metal which is fixed by a single bolt to a triangular bracket carried by two bolts on the dashboard. It is obvious that any vibration in the engine should be considerably damped by the fixing to the dashboard, which is of particularly robust and solid construction.

Delanghe, G. Les Progrès de la Construction Automobile Révélés par le Dernier Salon de Paris. Génie Civil, v. 101, no. 20, Nov. 12, 1932. p. 477-481. (figures)

In the section of the article entitled "Elastic Suspension of Motor", the author describes various measures taken in order to decrease the transmission of vibrations from the motor to the chassis.

Heldt, P. M. Flexible Engine Mountings Progress to Damping of Torsional as well as Reciprocatory Vibration. Automotive Industries, v. 66, no. 6, Feb. 6, 1932. p. 184-188, 193. (figures)

Discussion on automotive engine vibration. It was shown that if the power plant is supported in such a way as to be capable of a rocking motion around the axis, around which it tends to turn naturally, and its rocking motion is limited by a spring with suitable damping action, the transmission of torsional vibration from the power plant to the frame can be almost completely prevented.

Walker, H. Development of a Heavy-Duty V-12 Engine. S.A.E.-Jl. (Trans.), v. 30, no. 5, May 1932. p. 215-220. (figures)

Reasons for designing an engine with 12 cylinders for fire apparatus, motor trucks and motor coaches are set forth. Among them were the requirement for 225 hp., speed range of 200 to 3000 r.p.m. with little torsional vibration and torque reaction effect, and economy of space. Synchronism of impulses that causes torsional vibration can be avoided by an included angle of 30 degrees. Greater number of cylinders obviously produces a decreased torque vibration.

Bethenod, J. À Propos des Moteurs à Suspension Élastique. Soc. des Ingénieurs de l'Automobile-Jl., v. 6, no. 4, April 1933. p. 2146-2149.

Simple formulae are developed to show the conditions under which the phenomenon of resonance will not interfere with the functioning of an elastic engine suspension. Suggestion is then made for a damping device, the action of which varies automatically with engine speed.

Broulhiet, G. Independent Springing and its Effects on Suspension. S.A.E. Meeting Paper (Chicago), Aug. 28-Sept. 4, 1933. 45 p. (appendices, figures, bibliography)

Theory of resonance applied to vibrations in automobiles and other vehicles. Theory is very precise and in agreement with experiments. Its application requires that those constants necessary for calculations be determined. These values when applied correctly in manufacture of cars results in cars completely free from vibrations.

Caputo, A. Pourquoi Accroit-on sans Cesse le Nombre de Cylindres des Moteurs d'Automobiles. La Science et la Vie, v. 43, no. 187, Jan. 1933. p. 32-38. (figures)

The author explains a dependence between the vibrations and the number of cylinders in a motor and the forces of inertia of the second order. He gives a general description of anti-vibration arrangements of the Lanchester and Vauxhall motors.

Crane, H. M. Low Versatile Engineering Meets Public Demand. S.A.E.-Jl. (Trans.), v. 32, no. 1, Jan. 1933. p. 21-32. (references)

High speed engines gave rise to the problem of eliminating roughness of operation and preventing transmission of vibration to the chassis. Solution found in using a larger number of cylinders of small size and in the flexible suspension of engines of four and six cylinders.

Fuchs, H. O. Die Einflüsse von Schwingungsbremsen auf die Federung von Kraftwagen. Autom. Tech. Zeit., v. 36, no. 9, May 10, 1933. p. 230-237. (figures, references)
Also Automotive Industries, v. 69, no. 22, Nov. 25, 1933. p. 642-648.

Influence of shock absorbers on functions of springs in automobiles. Requirements of shock absorbers. Energy, balance of shock and origin of vibrations or oscillating energy; forces; duration of spring action; damping out of vibration; valuation of shock absorbers. Theoretical experimental analysis.

Jacklin, H. and Liddell, G. J. Riding Comfort Analysis. Purdue Univ., Res. Bul. No. 44, v. 17, no. 3, May 1933. 146 p. (appendices, figures, tables, bibliography) Also Automotive Industries, v. 68, no. 25, June 24, 1933. p. 758-762.

Report on progress of two investigations at the Engineering Experiment Station, "Measurement of Vibrations in Vehicles" and "Effects of Vibration on Humans", combing the results obtained into a method for numerically evaluating riding comfort. Details given of the Purdue Riding-Qualities Accelerometer, for analyzing motions of vehicles to determine their comfort, and the Purdue Vibrating Platform.

Kurt, O. E. An Analysis of Tires and Wheels as Causes of "Tramp". S.A.E.-Jl. (Trans.), v. 32, no. 5, May 1933. p. 191-196. (figures, equations)

Presents solution of factors in tires and wheels that cause a particular type of front-end vibration termed "tramp", which is a vertical vibration of the front axle accompanied by a small degree of simultaneous oscillation of the wheel assembly about the kingpin. This vibration, in turn, sets up the disturbance of the body and chassis. Theoretical action is developed in detail and supported by experimental results. Problems of the tire wheel and automotive engineers in eliminating this vibration are discussed.

Sarazin, M. Oscillations de Torsion des Vilebrequins. Soc. des Ingénieurs de l'Automobile, v. 6, no. 3, March 1933. p. 2098-2110. (appendix, figures, equations, discussion)

Methods and equipment of investigating torsional vibrations of automobile-engine crankshafts. The stroboscopic method of registration of the angular speed of a crankshaft is described. Methods of reducing torsional oscillations are suggested.

Shannon, J. F. Engine Damping Factors in Torsional Oscillation and the Effect of Vibration Form. Royal Technical College-Jl. (Glasgow), v. 3, part 1, Jan. 1933. p. 121-136. (figures, references)

The results of torsiographic investigations carried out on multi-crank engines are reduced to a simple non-dimensional damping factor. The variation in this factor is correlated to the vibration curve form at the engine and the average curve obtained is put forward as a guide in designs. These investigations were carried out on automobile engines.

Jürgensmeyer, - Die Walzläger und ihre Anwendung im Kraftfahrzeugbau. Autom. Tech. Zeit., v. 37, no. 5, March 10, 1934. p. 143-148.

The noise of bearings is largely a question of clearance. Discussion of design of various mountings for minimum play. Problem is difficult in the case of conical roller bearings, since the cones assume different positions when mounted under static friction and when running under vibration. Transition from one position to the other may take several hours.

Oeser, K. Schwingungen am Kraftfahrzeug und deren Isolierung gegen die Umgebung. Autom. Tech. Zeit., v. 37, no. 10, May 25, 1934. p. 277-279.

A popular exposition of the advantages accruing from the extensive use of rubber in mounting engine and back axle in the frame.

Pajus, J. Les Vitesses Critiques et les Oscillations de Torsion des Vilebrequins de Moteurs à Explosion. Tech. Autom. et Aérienne, v. 25, no. 164, 1934. p. 14-22. (figures)

Critical speeds and torsional oscillations on crankshafts of internal combustion engines. Theoretical mathematical analysis expounding Tolle method; simplification; methods in curves.

Riede, W. Messung der Biegungsschwingungen einer zweimal gelagerten Kurbelwelle in einem Vierzylindermotor während des Laufes. Autom. Tech. Zeit., v. 37, no. 14, July 25, 1934. p. 366-368. (figures)

Oscillations recorded optically by reflecting a beam of light from a mirror attached to the free end of the shaft. Under inertia forces only, the bending moment had three maxima per revolution. Vibrations modified by explosive forces. Cure suggested is the provision of an extra (central) bearing.

Söchting, F. Schwingungs-Höchstbeanspruchungen in Wellenleitungen. Autom. Tech. Zeit., v. 37, no. 12, June 25, 1934. p. 312-315. (figures, equations, references)

Maximum stress due to vibration in shafts. Theoretical, mathematical design analysis pertaining to automobile engine shafts. Curves and construction data in tables.

Taub, A. Resilient Mountings as Applied to Automotive Engines. S.A.E.-Jl. (Trans.), v. 34, no. 4, April 1934. p. 136-146. (figures)

Review of all developments in the field of resilient mountings of automotive engines, their primary use being insulation against noise and vibration. Discussion of the development of the six-cylinder engine in its relation to the elimination of secondary inertias of reciprocating units and torsional vibration. Analysis of engine roughness and its contributing causes. Desiderata for engine mountings.

Winslow, A. M. Cause and Effect of Vibration Shown. S.A.E. Meeting Paper (Northwest Section), 1934.

Causes of vibrations, with some specific examples. Classification of vibration: common or bouncing and torsional or transverse vibration. The use of the vibrometer, for measuring horizontal and vertical motion as in spring action discussed. The function of shock absorbers, springs and other instruments designed to dampen and halt vibration is given in some detail. Explanation of crankshaft failure due to torsional vibration and difficulty of avoiding all bad amplitudes in the automobile engine, due to variation in speed.

Benz, W. Biegungsschwingungen von Kurbelwellen insbesondere bei schweren Schungrädern. Autom. Tech. Zeit., v. 38, no. 16, Aug. 20, 1935. p. 405-408. (figures, equations, references)

The special case of torsional vibration of crankshafts here considered is that of shafts with especially heavy flywheels. Results of an experimental investigation are reported and a method of theoretical calculation is discussed.

Morris, J. Crankshaft Vibration. Automobile Engineer, v. 25, no. 329, Feb. 1935. p. 6-12. (figures, tables)

Author's trigonometric mode of solution for torsional vibration problems, as given in his book "Strength of Shafts in Vibration", gives compact and simple quantitative expressions for amplitudes of various orders of forced vibration of throws of a crankshaft, account being taken of sequence of firing.

Rausch, E. Schwingungen von Kraftfahrzeugen. Autom. Tech. Zeit., v. 38, no. 23, Dec. 10, 1935. p. 580-586. (figures, equations)

Theoretical mathematical analysis pertaining to vibrations in symmetrical plane and vibrations perpendicular to symmetrical plane, and their application to design of automobile springs and suspensions. Practical examples.

Süss, G. Drehschwingungen in der Triebwerksanlage von Lastkraftwagen. Fördertechnik und Frachtverkehr, v. 28, no. 5-6, March 8, 1935. p. 49-55. (figures, equations, references)

Vibrations resulting from rotation in the power transmission of trucks. Theoretical analysis and calculation of vibrating forces.

Waas, H. Messung von Kraftfahrzeugschwingungen. Z.V.D.I., v. 79, no. 7, Feb. 16, 1935. p. 199-202. (figures)

Measurement of vibrations of automobiles. Description of measuring equipment developed in Germany with which comparative tests on various cars may be made. Results of measurements.

Wilson, W. K. Torsional Vibration in Automobile Engine Crankshafts. Inst. Automobile Engineers-Jl., v. 4, no. 1, Oct. 1935. p. 42-97.

Simple practical treatment of torsional vibration problems encountered in design of automobile engine crankshafts and methods of obtaining smooth performance throughout the speed range are discussed.

d'Aubarède, P. Etude sur les Vibrations des Automobiles. Soc. des Ingénieurs de l'Automobile-Jl., v. 9, no. 6, Aug. 1936. p. 258-268. (figures, discussion)
Also La Science Aérienne, v. 5, no. 5, Sept.-Oct. 1936. p. 247-267.

Analysis was made of the vibrations of an automobile engine in operation. Applying the analysis practically, the author then discusses the location and design of rubber mounting blocks to damp and isolate these vibrations.

Gerdan, D. Engine Block Design. Automotive Industries, v. 75, no. 8, Aug. 22, 1936. p. 242-244.
Discussion S.A.E.-Jl., v. 38, no. 2, Feb. 1936.
Also Tech. Autom. et Aérienne, v. 27, no. 174, 1936. p. 91-93.

Design with full-length water jacket and box-girder type of support for bearings found to have increased rigidity. Roof of crankcase can be reinforced to minmize transverse vibration.

Heldt, P. M. Engine Roughness - Its Cause and Cure. S.A.E.-Jl. (Trans.), v. 38, no. 2, Feb. 1936. p. 47-54. (figures)
Discussion v. 38, no. 3, March 1936. p. 35.
Also Tech. Autom. et Aérienne, v. 27, no. 173, 1936. p. 40-47.

Thesis is maintained that roughness consists of synchronous transverse vibration of crankcase, due to variations in gas pressure and inertia forces.

Jacklin, H. M. Human Reactions to Vibrations. S.A.E.-Jl. (Trans.), v. 39, no. 4, Oct. 1936. p. 401-408. (figures, discussion)
Also Automotive Industries, v. 74, no. 2, June 27, 1936. p. 908-909.

Presenting the analysis of several thousand observations of the reactions of humans to vibration when sitting on a controlled vibrating seat or platform and in moving vehicles. Physical reactions are defined carefully as a result of many experiments under controlled conditions. The perfection of a three-directional wave-recording accelerometer is described. Its use in determining vibration conditions when the defined physical reactions occur is displayed. The relative effects of vibration in three directions on hard and upholstered seats are disclosed together with suggested instrumentation with the accelerometer. The rating of vehicles of transportation by a comfort scale is easily accomplished by the use of the accelerometer.

Lanchester, F. W. Motor-Car Suspension and Independent Springing. Engineering, v. 141, no. 3665, April 10, 1936. p. 394-396; no. 3667, April 24. p. 464-465. (figures)

Analysis of problems of design.

Lemaire, P. Les Etouffeurs Dynamiques de Vibration. La Science Aérienne, v. 5, no. 4, July-Aug. 1936. p. 223-238. (figures)
Also Soc. des Ingénieurs de l'Automobile-Jl., v. 9, no. 7, Sept.-Oct. 1936. p. 297-305.

The author's thesis is that automotive engineering problems aside from thermo-dynamics, and those of electrical engineering, are not only analogous but identical. As an example, he develops from Ohm's laws, formulae and analyses applicable to dynamic vibration dampers. He urges that in research, for both economy of time and money, mechanical problems be treated according to electrical theory.

Lemaire, P. and d'Aubarède, P. Qu'est-ce que le Montage "Pansodyne." La Science et la Vie, v. 49, no. 227, May 1936. p. 405-413. (figures)

The authors describe in detail the origin of vibrations in automobiles and, by analysis of resonance, inertia forces and their influence on buffer springs. Describes "Pansodyne" mounting of motors.

Marquard, E. Zur Schwingungslehre der Kraftfahrzeugfederung. Autom. Tech. Zeit., v. 39, no. 14, July 25, 1936. p. 352-361. (figures, references)

Mathematical method of determining the frequencies, amplitudes, and accelerations of natural vibrations of various undamped suspension systems. Critical discussion of the method leads to the conclusion that it has practical applicability. Examples of its use are given.

Parkinson, J. S. and Young, P. O. A Technique for Studying the Efficiency of Panel Damping Materials. Amer. Acous. Soc.-Jl., v. 7, no. 4, April 1936. p. 281-286.

Such materials are widely used in body panel of automobiles. Method developed whereby relative efficiency of damping materials may be determined. Method has been correlated with ear judgments and found to give satisfactory results. The term "vibrational decay time" is proposed, which is time required for the amplitude of sheet or panel to decay to 1/1000 of its original value.

Riekert, P. and Ernst, H. Messung von Biegeschwingungen an einem Fahrzeug-Dieselmotor Kraftfahrtechnische. Forschungsarbeiten, no. 5, 1936. p. 1-8. (figures, tables)

Describes tests of the bending vibrations in the three-bearing crankshafts of a four-cylinder Diesel automobile engine.

Wassutinsky, S. Différentes Formes des Vibrations de Torsion des Arbres Vilebrequins. Tech. Autom. et Aérienne, v. 27, no. 173, 1936. p. 48-51. (figures, table)

Theoretical, mathematical study pertaining to vibrations of automobile-engine crankshafts.

VIBRATION STUDIES IN ALLIED FIELDS - DIESEL ENGINES

Goldsbrough, G. R. Torsional Vibrations in Reciprocating Engine Shafts. Roy. Soc.-Proc., v. 109, no. A749, Sept. 1, 1925. p. 99-119. (figure)

Theory of torsional oscillations of slow-running shafts in reciprocating engines, especially of a six cylinder or four-stroke cycle Diesel engine. Usual theory replaces pistons, rods, cranks, etc. by equivalent masses. The author attempts to correct for these approximations by assuming that shafts are rigid. Values of critical speeds show moderate departures from the simple theory which may be insignificant in practice.

Fox, J. F. Some Experiences with Torsional Vibration Problems in Diesel Engine Installations. Amer. Soc. Nav. Engrs.-Jl., v. 38, no. 3, Aug. 1926. p. 695-719. (figures)

Discussion of problems involving torsional vibration encountered by the N. Y. Navy Yard.

Lewis, F. M. Torsional Vibration in the Diesel Engine. Marine Eng'g. and Shipping Age, v. 31, no. 7, July 1926. p. 415-423. (figures, bibliography)

Review of the more fundamental aspects of torsional vibration in the Diesel engine. Natural frequencies of vibration are calculated and there is a discussion of vibration in multi-cylinder engines, types of installation and their vibration characteristics, elimination of vibration, speed regulation and the action of the flywheel.

Magdeburger, E. C. Vibrations in Oil Engine Crankshafts. Power, v. 68, no. 15, Oct. 9, 1928. p. 595.

The author refers to and amplifies an article by W. E. Warner in the July 31 issue of the journal. He discusses two kinds of vibration, flexural and torsional, and instruments for recording them.

Porter, F. P. The Range and Severity of Torsional Vibration in Diesel Engines. A.S.M.E.-Trans., v. 50, APM 50-8, 1928. p. 25-61. (figures, tables, references)

General treatment of the subject of the torsional vibration of irregular shafts. Illustrations are given of examples of computations for the shafting of certain Diesel engine installations that have been investigated. Material presented is the result of a study to determine accurately the range of vibrations and the speeds at which they occur. Data also give the results of a study on the effect of elastic hysteresis and other damping forces in determining the maximum vibration at the various critical speeds.

Porter, F. P. The Range and Severity of Torsional Vibration in Diesel Engines. A.S.M.E.-Trans., v. 50, APM 50-14, 1928. p. 45. (figure)

The author has developed another treatment of the matter published in A.S.M.E.-Trans., v. 50, APM 50-8, 1928. p. 25-61.

Schläpfer, O. New Diesel-Electric Locomotives for the Russian Railways. Brown Boveri Review, v. 15, no. 10, Oct. 1928. p. 298-299.

Discussion of the Diesel-electric locomotives used in Russia. Certain changes introduced in these locomotives, e.g. different type of coupling used thus affecting the inherent period of oscillation of the system so that all critical speeds lie outside the normal speed range of the locomotive.

Ford, L. R. Maintenance and Repair of Marine Diesel Engines. Mechanical Engineering, v. 51, no. 8, Aug. 1929. p. 576-580.

Included is a brief discussion of the breakage of crankshafts due to torsional vibration, a much less common source of trouble than in former years. An interesting case demonstrating the destructive effects of torsional vibration in crankshafts is cited.

Magdeburger, E. C. Torsional Vibrations Break Crankshafts. Power, v. 69, no. 9, Feb. 26, 1929. p. 371-373. (figures)

Scientific discussion of torsional vibration in crankshafts and analysis of vibration failures in engines. Cause of torsional vibration is elasticity of shaft material, which tends to bring back to their normal state deflected fibres of shaft; frequency of vibration depends on torsional stiffness. Discussion of instruments to measure torsional vibrations, variable speed of naval propelling plants, shaft failures on naval steam engines, and Diesel-engine shafts.

______________ Determining the Natural Periods of Vibration of Multi-Cylinder Diesel Engines. Sulzer Technical Review, no. 2, July 1930. p. 12-14. (figures, equations)

Calculation and graphical methods of solution.

______________ Torsional Deflection in Diesel Crankshafts. Power, v. 72, no. 7, Aug. 12, 1930. p. 248-250. (figures)

Results of tests made recently at Oregon State College to determine the difference in crankshaft distortion between load and no load.

______________ Determining the Natural Periods of Vibration of Multi-Cylinder Diesel Engines. Mechanical World, v. 88, no. 2283, Oct. 3, 1930. p. 322-324. (figures, equations)

Simplified theoretical treatment of solution by calculation and graphical method.

Behrens, H. Näherungsrechnung der Drehschwingungszahlen von Mehrzylindermaschinen. Werft-Raederei-Hafen, v. 11, no. 3, Feb. 7, 1930. p. 55-59. (figures)

Development of a simple direct method of approximately determining frequency for the case of multi-cylinder engines having one flywheel. The author generalizes his investigation work in the form of special charts to admit of determination of any critical. The method is illustrated by application to cases having from one to eight cylinders.

Bradbury, C. H. Torsional Vibration Problems in Geared Marine Diesel Machinery. Mechanical World, v. 88, no. 2288, Nov. 7, 1930. p. 434-436. (figures, equations)

Discussion of the increasing tendency to adopt mechanical reduction gearing for marine Diesel engines. For this gearing to be completely successful, continuous positive torque must be obtained so that there will at no time be any negative thrust on gear teeth. The question of torsional vibration is carefully considered.

Den Hartog, J. P. and Ormondroyd, J. Torsional Vibration Dampers. A.S.M.E.-Trans., v. 52, APM 52-13, 1930. p. 133-152. (figures, references, discussion)

A theory of the action of friction dampers on systems in torsional resonance, presented with special application to gas and Diesel engine installations. Model tests carried out to check this theory are described. The effect of introducing springs in the Lanchester damper is also discussed.

Geiger, J. Biegungsschwingungen von Maschinen. Z.V.D.I., v. 74, no. 17, April 26, 1930. p. 542-544. (figures)

The side pressure of the piston on the cylinder wall subjects the engine and its foundations to periodic forces in the plane at right angles to the crankshaft, which is specially important in large Diesel engines. The resulting vibrations were recorded by the author's vibrograph. By suitable arrangement, the transverse vibration was reduced.

Geiger, J. Diesel Locomotive Design. Railway Engineer, v. 51, no. 608, Sept. 1930. p. 349-354; no. 610, Nov. p. 425-428. (figures)

Advantages and disadvantages of various transmission systems are discussed and underlying principles of Diesel-compressed-air locomotive are outlined. Vibration rising from Diesel engine and from transmission system in locomotives. Torsiogram for six-cylinder Diesel-electric unit. Torsional oscillations in Diesel-electric, geared-Diesel and Diesel-compressed-air locomotives.

Göller, E. Zur Berechnung von Drehschwingungen bei Dieselmotorenanlagen. Z.V.D.I., v. 74, no. 16, April 19, 1930. p. 497-498. (figures, equations, references)

Development of two simplified formulae for calculating frequencies of systems, "engine-single mass" and "engine-two single masses". Graphs showing relations of variables; numerical example.

Maleev. B. V. L. Torsional Vibrations and Critical Speeds in Diesel-Generators. Power, v. 71, no. 22, June 3, 1930. p. 861-864. (figures)

Method given of figuring critical speeds produced by torsional vibration of crankshafts of Diesel engines direct-connected to a.c. generators. Discussion of how design of Diesel, particularly of its flywheel, is influenced by requirements of parallel operation.

Sandner, E. Torsional Vibrations. Motorship, v. 15, no. 9, Sept. 1930. p. 586-587.

Discussion of the order of desirability of 10, 8, and 16 cylinder high-speed Diesel engines from the point of view of torsional vibrations.

Behrens, H. Zur Berechnung in der Resonanz auftretenden Schwingungsausschläge und Schwingungsbeanspruchungen der Wellenleitung von Motoranlagen. Werft-Raederei-Hafen, v. 12, no. 6, March 15, 1931. p. 94-99. (figures)
Also Marine Engr. and Motorship Bldr., v. 54, no. 644, May 1931. p. 197-198.

In the calculation of torsional oscillations it is necessary to determine natural frequency of shafting, which critical revolutions are most dangerous, and how far service revolutions must be displaced from critical revolutions to ensure safety. The calculation work involved in such an investigation is presented.

Bradbury, C. H. Torsional Vibration in the Diesel-Electric Set. Inst. Elec. Engrs. (G.B.)-Jl., v. 69, no. 418, Oct. 1931. p. 1295-1302. (figures, references)

Discussion of the general methods of determining natural frequencies of simple systems, and methods of reducing Diesel engine and generator to system suitable for calculation. Examination is made of modes of vibration most commonly encountered in practice and method of discriminating between major and minor critical speeds. Damper and torsiograph are described. Actual examples are given of sets in which torsional resonance has been encountered.

Grey, R. B. The Elimination of Vibration. Diesel Engine Users Assoc., Rep. No. 3103, Nov. 5, 1931. p. 1-31. (appendix, figures, discussion)

Also Mechanical World, v. 90, no. 2342, Nov. 20, 1931. p. 505-508.

Discussion of a method of reducing vibrations of Diesel engines by proper balancing and mounting on elastically supported foundation. Discussion relating to experience with stationary and machine installations. Appendix shows typical vibrograph records.

Kjaer, V. A. Vibrations de Torsion dans les Vilebrequins des Moteurs Diesel. Technique du Bureau Veritas-Bul., v. 13, no. 5, May 1931. p. 94-98. (figures, equations)

Advance calculation of factors controlling torsional vibration. Importance in variation of natural frequency. Experimental determination of damping coefficients. Stopping and starting forces discussed.

Laudohn, W. Schnellaufende Dieselmotoren. Glasers Annalen, v. 109, no. 8, Oct. 15, 1931. p. 69-75. (figures)

Discussion of balancing of masses and damping of vibrations in high speed Diesel engines. Friction dampers by Man and Maybach, hydraulic damper by Sandner and Junkers, and superchargers by Zoller and Lorenzen are discussed.

Miller, R. A. Torsional Vibrations in Small Diesel Installations. Marine Eng'g. and Shipping Age, v. 36, no. 7, July 1931. p. 328-329. (figures)

The author relates that serious failure of shafting in Diesel-engine installations often proves, on investigation, to be due to torsional vibration, and cites instances. The suggestion is made that it would prove profitable to owners to have torsional vibration calculations made for all Diesel-engine drives and to check up on these with torsiograph readings during trial trips.

Rosen, C. G. A. A Survey of Mobil-Type Diesel Engines. S.A.E.-Jl. (Trans.), v. 28, no. 3, March 1931. p. 301-306. (figure, discussion)

Discussion of the major problems involved in the designing of high-speed Diesel engines: combustion chamber design; fuel-injection methods and devices; flexibility in utilization of variety of cheap low-grade fuels; completeness and smoothness of combustion; reduction of vibration; low first cost and maintenance.

Sandner, E. and Barraja-Frauenfelder, J. Practical Experiences with Devices for Damping Torsional Vibration. S.A.E.-Jl., v. 29, no. 6, Dec. 1931. p. 458-469. (figures, references, discussion)
Also Tech. Autom. et Aérienne, v. 23, no. 156, 1932. p. 27-31,45-51.

Elementary principles of torsional vibrations stated and usual methods of damping classified. Descriptive details of a hydraulic throttling damper applied to a 10-cylinder marine Diesel. Torque diagrams reproduced with and without damping and show reduction of torsional oscillations, from approximately double the torque variation to negligible proportions. Resonance curves reproduced, showing a high peak without damper and a comparatively small rise with damper. In discussion, experiences of designers in meeting the problem are described.

Taylor, J. L. Torsional Vibration Frequencies of Marine Diesel Installations. Engineering, v. 131, no. 3397, Feb. 20, 1931. p. 259-260. (figure, equations)
Discussion v. 131, no. 3401, March 20, 1931. p. 420.
v. 131, no. 3404, April 10, 1931. p. 480.

Attempt is made to deduce frequency in which it is only necessary to substitute appropriate data, shaft lengths, stiffnesses and moments of inertia for any installation. Various solutions of this equation give immediate natural frequencies of various modes and hence critical speeds. This greatly reduces labor and avoids the necessity for any graphical work.

Taylor, J. L. Torsional Vibration Amplitudes of Marine Diesel Installations. Engineering, v. 131, no. 3411, May 29, 1931. p. 694-696. (equation, table)
Discussion v. 131, no. 3415, June 26, 1931. p. 835.
v. 132, no. 3416, July 3, 1931. p. 22
v. 132, no. 3417, July 10, 1931. p. 40

Method of calculation proposed, showing relation to general theory of vibrations, consists in extending the idea of "equilibrium amplitude"(when subject to force or series of forces) to systems without constraint and then multiplying by usual "dynamic magnifier" to obtain actual forced amplitude.

Willson, T. E. Isolating Diesel Engines Against Vibration. Diesel Power, v. 9, no. 11, Nov. 1931. p. 557-559. (figures)

Review of general causes of machinery vibration, with special regard to Diesel engine installations. Suggestions as to remedies and means available for correction.

Baer, H. Messung der Drehschwingungen an einem 1500 PS-Dieselmotor. Z.V.D.I., v. 76, no. 28, July 9, 1932. p. 689. (figures)

Torsional oscillations of a 1500 h.p. Diesel engine investigated. Torsional vibration was measured at free shaft end of engine as engine came to rest after full speed. Experiments with and without belts and with coupling disconnected showed that vibration characteristics of engine were practically unaffected by presence of a second flywheel, which was completely isolated by leather belt and pulley.

Ford, L. R. Repair Problems of Marine Diesel Engines. S.A.E. Meeting Paper, Nov. 1932.

Discussion of torsional vibration as a cause of breakage of crankshafts in Diesel engines. Torsional vibration can be avoided by calculation of criticals before engine is built. The Brooklyn Navy Yard has done wonderful work in the matter of torsional vibration and is far advanced in their analyses to detect critical periods and ways of handling them.

Klopper, J. Fundeering Met Rubber. Ingenieur (Hague), v. 47, no. 27, July 1, 1932. p. B126-B128.

High-speed Diesel engine caused vibrations in proximity. Mounting of engine on rubber cushions proved to be successful in eliminating vibrations. Analysis of case and construction details.

Rosenzweig, S. Isolating Machine Vibration and Noise. Diesel Power, v. 10, no. 5, May 1932. p. 199-201.

General and theoretical considerations involved in the study and prevention of vibration transmission and means available for its effective isolation. Photographs and outline drawing of foundations prepared for 2865 h. p. McIntosh and Seymour Diesel engine that is being installed in the municipal electric light plant at Rockville Center, L.I., N.Y.

Wilson, W. K. Torsional Vibration Characteristics of Six-Cylinder,Four-Stroke Cycle, Single-Acting Oil Engines. Gas and Oil Power, v. 27, no. 323, Aug. 4, 1932. p. 168-174.

Methods available for modifying torsional vibration characteristics of a given system. Methods of altering natural frequencies of torsional vibration of any given system. Vibration stress values; methods of modifying torsional vibration stresses in marine installations. Curves illustrating torsional vibration characteristics.

Wilson, W. K. Torsional Vibration Characteristics of Six-Cylinder, Four-Stroke Cycle, Single-Acting Oil Engines. Gas and Oil Power, v. 27, no. 325, Oct. 1932. p. 213-214.

Vibration stress diagram for marine installation. Normal crank and balance-weight arrangement. Effect of reducing magnitude of flywheel and crankshaft balance weights.

Hirosawa, S. Torsional Vibration of Shafting. Soc. Naval Architects (Japan)-Jl., v. 51, April 1933. p. 109-134. (In Japanese)

Method of calculating critical speeds of shafting in Diesel ships described so that meanings and natures of vibration can be easily comprehended.

Jackson, P. The Vibrations of Oil Engines. Diesel Engine Users Assoc., Rep. No, S115, April 26, 1933. p. 1-52. (figures, references, discussion, bibliography)

Any periodic force, couple or torque can cause vibration in elastic structures of heavy-oil engines. Inertia forces and those arising from irregularity of propulsive effort; unbalance forces; balancing of engines; vibration of foundations; comparison of vibration of various engines; torque variation; cyclic irregularities; angular deviations; flicker; resonance; torsional vibration.

Popoff, W. Resonanz-Drehschwingungsdämpfer mit Werkstoffdämpfung für Kurbelwellen von Dieselmotoren. Z.V.D.I., v. 77, no. 1, Jan. 7, 1933. p. 19-23. (figures, tables, references)

Resonance torsional oscillation damper with solid damping for crankshafts of Diesel engines investigated. Description of damper given. Numerical results given graphically and in tables, and show beneficial effects of damping in several installations. Four oscillograms reproduced. Results of tests on 500 h.p. stationary and 80 h.p. automotive Diesel engines. Reduction of amplitude by 50% at critical speeds.

Bara, H. Note au Sujet de l'Amortissement des Oscillations de Torsion des Arbres Moteurs des Bâtiments à Moteurs Diesel. Technique du Bureau Veritas-Bul., v. 16, no. 7, July 1934. p. 137-140. (equations, references)
Also Assoc. Technique Maritime et Aeronautique, Bul. No. 38, 1934. p. 627-640.

Note on the subject of damping of torsional vibrations of shafting in motorships. Formula giving amplitude of oscillations taking into consideration damping due to propeller when ship is in high sea. Calculation of damping as applied to submarines.

Schmidt, T. Schwingungen in Auspuffleitungen von Verbrennungsmotoren. Forschung aus dem Gebiete des Ingenieurwesens, v. 5, no. 5, Sept.-Oct. 1934. p. 226-237.
Also Z.V.D.I., v. 79, no. 1, Jan. 5, 1935. p. 27-28. (figures, references)

Vibrations in exhaust pipes of internal combustion engines; scavenging; theoretical considerations. Tests carried out on two-stroke precombustion-chamber of a Humboldt-Deutz Diesel engine.

Wilson, W. K. Calculation of Torsional Vibration Stresses of Marine Oil-Engine Installations. Engineering, v. 137, no. 3553, Feb. 16, 1934. p. 167-170. (figures, discussion)

Mathematical article dealing with resonant torsional vibrations, particularly those occurring at critical speeds corresponding to the two-node mode of torsional vibration as well as at critical speeds corresponding to the one-node mode of vibration. Analyzes principal engine damping forces and gives methods by which approximate solutions for evaluating engine damping factors may be obtained. Also proposes an alternative method for calculating the amplitude of torsional vibration at resonant speeds, using J, which is the moment of inertia of the oscillating mass of working cylinder.

Dickson, J. The Diesel Engine for Rail Transportation. Mechanical Engineering, v. 57, no. 7, July 1935. p. 547-552. (figures)

Diesel engines as the motive power in high-speed, lightweight trains. Problem of critical speeds is a fundamental one with this type of engine. Problem of torsional vibration discussed and a few elementary factors involved given. The use of a torsional vibration damper is explained.

Brabec, F. Oscillations de Torsion des Groupes Generateurs Diesel-Electrique. Revue Générale de l'Electricité, v. 40, no. 23, Dec. 5, 1936. p. 715-726. (figures, equations, table, references)

Author divides the problem into three parts: (1) determination of frequency of free torsional oscillations; (2) determination of dangerous critical speeds; (3) determination of coefficient of irregularity.

Nakanishi, F. Vibrations of Automatic Fuel Valves. Soc. Mech. Engrs. (Japan)-Trans., v. 2, no. 86, Feb. 1936. p. 5-10. (In Japanese)

It occurs often in airless-injection engine having nozzles with automatic fuel valves, that injection cannot be cut off in time owing to vibration of automatic valve at end of injection. It was found that such vibration can be avoided by selecting suitable size fuel pipe, although there is considerable length from fuel pump to nozzle.

Seewer, E. U. Critical Speeds and Vibration Amplitudes of a Six-Cylinder Diesel Engine. Diesel Power, v. 14, no. 9, Sept. 1936. p. 583-585.

Flexibility of crankshaft and variable engine torque of any reciprocating engine are two fundamental causes of torsional vibrations. It is of vital importance that engineers know the exact location of different critical speeds and investigate whether these amplitudes may be the cause of fatigue failure or of intolerable noise in gear train. Simplified method of calculating critical speeds and vibration amplitudes given.

______________ Cluster Valve Springs. Scientific American, v. 132, no. 6, June 1925. p. 414. (figure)

Discussion of failures in high speed engines due to the synchronism of the firing impulses with the vibration of the valve springs. Remedy is to make the period of vibration of the springs much faster.

Cormac, P. Engine Balance. Scientific American, v. 133, no. 1, July 1925. p. 33-34; no. 2, Aug. p. 133-134. (figures)

July - A diagrammatical explanation of the resolution of forces for counterbalancing vibration. Example given of inertia of rotating masses. Principle of partial balance for single cylinder and multi-cylinder engines. Balance in four-cylinder, straight line eight, and offset-cylinder engines. Aug. - The application of the two-circle method to radial and V engines shown in the analyses of the balance of the eight cylinders set at right angles, the rods of corresponding cylinders sharing the same crankpin.

Lack, A. and Jahnke, C. B. Torsional Vibrations and Critical Speeds of Shafts. A.S.M.E.-Trans., v. 47, no. 1969, 1925. p. 493-523. (figures, discussion)

Analysis of torsional vibrations and critical speeds of shafts. These magnitudes can be calculated, as shown here, for any engine, when all necessary data are given. Various characteristics of torsional vibrations are measured with the torsiograph which shows on torsiograms the degree of irregularity of rotation. Stresses in the shaft due to its vibrations computed, and means of avoiding dangerous vibrations shown. Results of tests performed on a number of engines.

______________ Killing Vibration. Scientific American, v. 134, no. 7, July 1926. p. 42-43. (figures)

Previous methods of obtaining balance and eliminating vibration in high-speed, internal combustion engines have been procedures preliminary to manufacture. Now a method has been perfected which adds the further refinement of locating the unbalanced masses in the finished product itself, both as to their total moment and their plane of location. It is the Gisholt precision balancing machine which can be used for balancing crankshafts, flywheels and other rotor parts. Unit used in balancing machine is the "ounce inch". Dynamic balance analyzed. Description of the precision balancing machine.

Goldsbrough, G. R. The Properties of Torsional Vibrations in Reciprocating Engine Shafts. Royal Soc.-Proc., v. 113, no. A764, Dec. 1, 1926. p. 259-271. (figures)

Description of a model for investigating the effect of reciprocating parts of torsional vibration and results obtained. Qualitative agreement with theory.

Goldsbrough, G. R. and Baker, H. The Properties of Torsional Vibrations in Reciprocating Engine Shafts. Royal Soc.-Proc., v. 113, no. A 764, Dec. 1. 1926. p. 272-281. (figures)

Summary of torsional effects which appear with variation in speed. Use of torsiograph and experimental shaft model to check qualitatively the theoretical predictions in first part of the paper.

Treves, S. R. Sulle Velocita Critiche degli Alberi a Gomiti. L'Industria(Milan), v. 40, no. 14, July 13, 1926. p. 369-371; no. 15, Aug. 15. p. 395-397; no. 16, Aug. 31. p. 424-426. (figures, equations)

Discussion of the necessity for accurate calculation of crankshafts, including critical velocity, to determine dimensions, etc., giving the greatest safety in operation; types of critical velocity; critical torsional velocity.

Cornock, A. F. The Torsional Oscillations of a Crankshaft. Machinery(London), v. 29, no. 752, March 10, 1927. p. 739-740. (figures)

Investigation of corrections of existing assumptions concerning torsional oscillations of crankshafts.

Vogt, F. Über schadliche Schwungmassen bei Drehschwingungen. Z.V.D.I., v. 71, no. 35, Aug. 27, 1927. p. 1221-1223. (figures, equations)

Case of rotating shaft loaded with n flywheels examined, one of the flywheels being actuated by means of periodic couple. From the general solution for resultant amplitude of vibration for any one wheel, the special case of a three-flywheel system is deduced. Under certain conditions, smoother running is obtained without a flywheel, the torsional oscillations of the system with the flywheel in position being greater than that due to the irregularity of the engine without the flywheel.

Bloomfield, J. M. Vibration from Internal Combustion Engines. Power House (Toronto), v. 22, no. 10, May 20, 1928. p. 35-36.

Causes of vibration are subsoil, periodic forces and misfiring; primary and secondary forces. Several methods of absorption and damping of foundation vibrations.

Gorfinkel, A. Vibrations de Torsion dans les Moteurs Polycylindriques. Génie Civil, v. 92, no. 21, May 26, 1928. p. 513-515; no. 22, June 2. p. 533-537. (figures, tables, equations, references)

May - Method of calculation of the natural frequency and elastic stresses of a shaft. Reduction of masses; critical speeds; damping couples. June - Harmonic analysis of indicator cards. Graph of coefficients and m.e.p.; elastic stresses; influence of connecting rod, piston and inertia forces in general on the vibration; harmonic analysis of torque caused by reciprocating parts.

Hort, W. NeuereForschungen über mechanische Schwingungen. Z.V.D.I., v. 72, no. 32, Aug. 11, 1928. p. 1118-1122. (figures, references)

Theory of vibrations dealt with under three headings: (1) the loading of rotating parts in engines; (2) failures due to vibration; (3) the measurement of vibrations including noise. The vibration meters built by Geiger and Ohniusen compared.

Norman, C. A. and Stinson, K. W. The Distortion of Crankshafts. S.A.E.-Jl. (Trans.), v. 23, no. 1, July 1928. p. 83-86. (figures)

References to articles and books on the nature of torsional vibration of crankshafts. Because published experimental data on deflections (angular distortion under given torques) are lacking, the authors obtained an engine with four crankshafts having crank-arms with different cross-sections, and measured the deflections under static load. Deflections in various parts of the shafts are analyzed and compared, and a formula is developed for the deflection in the long crank-arms of the shaft.

Alcock, J. F. and Glyde, H. S. The Torsional Stiffness of Crankshafts. Automobile Engineer, v. 19, no. 255, June 1929. p. 211-214. (figures)

The problem of calculating torsional stiffness in crankshaft of high-speed engines is considered. Deflections which occur in single crank-throw subjected to torsion. Cases considered of single-throw crank with journals angularly free and with journals encastré. General method of calculating natural period of oscillation of crankshaft. Test figures correspond to critical speeds obtained by calculation.

Cormac, P. The Design of Dynamically-Balanced Crankshafts for Two-Stroke-Cycle Engines. Engineering, v. 128, no. 3326, Oct. 11, 1929. p. 458-461. (tables)

In general, with two-stroke engines, best balance is obtained only when definite firing order is combined with special spacing of cylinders, whereas with engines of less than five cylinders in line it is not possible to obtain complete primary balance. Out-of-balance effects should be minimized by using suitable counter-balance masses on crankshaft. Cases considered of 2,3,4,5,6,7, 8,9,10,12,14 and 16 cylinders.

Gorfinkel, A. Critical Speeds of Crankshafts. Engineering, v. 128, no. 3337, Dec. 27, 1929. p. 827-829. (figures, tables, references)

The author explains how calculation for torsional vibration may be simplified and results sufficiently exact for practical requirements attained with reasonable ease and rapidity. The method described originated in connection with designs of Diesel engines but are applicable to all multi-throw crankshafts.

Hooker, R. J. Torsional Vibrations in the Crankshafts of Engines. Minnesota Techno-Log, v. 10, no. 3, Dec. 1929. p. 82-83. (figures)

Development of time-displacement curve for free sinusoidal vibrations, and of forced vibrations. Resources curve for forced vibrations. Gas-pressure torque curve for 4-stroke cycle Diesel engine. Details of moving parts of the Geiger torsiograph.

Jehle, F. and Spiller, W. R. Idiosyncrasies of Valve Mechanisms and Their Causes. S.A.E.-Jl. (Trans.), v. 24, no. 2, Feb. 1929. p. 133-143. (appendix, figures)

Description of the valve-lift-curve indicator which gives a photographic record of the valve-lift curve, and also of a spring-vibration indicator which makes a record of the actual vibration of the spring on the same film with the valve-lift curve. A formula is given which includes harmonic analysis of the valve-lift curve and characteristics of spring. The formula is also given for calculation of the frequency of the spring in terms of its dimensions. The appendix gives sample calculation of the harmonics of the cam and the mathematical derivation of the general equation for spring vibration amplitude.

Morris, J. The Effect of the Damping of the Throws on the Torsional Vibration of the Crankshaft System of an Internal Combustion Engine. Roy. Aero. Soc.-Jl., v. 33, no. 227, Nov. 1929. p. 1086-1087. (figures)

Mathematical treatment of the effect of the damping of the throws on the torsional vibration of the crankshaft system of an internal combustion engine.

Porter, F. P. Practical Determination of Torsional Vibration in an Engine Installation which May Be Simplified to a Two-Mass System. A.S.M.E.-Trans., v. 51, APM 51-22, 1929. p. 239-263. (appendices, figures, tables, references)

Practical solution given for torsional vibration in the shafting of a reciprocating-engine installation which may be reduced mathematically to a simple two-mass system. Methods are presented for computing the damped vibrations in installations where the damping forces follow various laws. Particular attention is given to such damping forces as are caused by a marine propeller, elastic hysteresis, and a friction damper. Illustrated examples of computations for certain engine vibrations that have been investigated.

Stodola, A. Drehschwingungen von Mehrkurbelwellen. Z.A.M.M., v. 9, no. 5, Oct. 1929. p. 349-360. (figures, equations)

Linear differential equations of motion formed for torsional oscillation in multiple crankshafts with the usual assumption of linear damping, which enables the system to be solved simply. Equations developed for seven masses connected elastically, and a numerical example is worked out. A case of apparent resonance is discussed, and it is shown, in certain conditions, not to be dangerous. Undamped oscillations are also briefly treated.

Voelckel, K. and Kissinger, H. Untersuchungen Schwingungserscheinungen in der Expansionslinie der raschlausenden der Dressungs-Kraftmaschinen. Autom. Tech. Zeit., v. 32, no. 30, Oct. 31, 1929. p. 670-672; no. 31, Nov. 10. p. 702-705. (figures)

Theoretical and practical investigations of the nature of vibrations in high-speed engines. Tests were carried out on a single cylinder Horex engine making use of optical indicator of OSA-Apparate Gesellschaft, Frankfort. Relation of fuel to vibration was determined which led to conclusions regarding the cause of vibrations.

________________ Critical Speed in an Engine Shaft. Power, v. 72, no. 25, Dec. 16, 1930. p. 973-974.

Practical discussion of the reasons for excessive vibration of crankshafts at certain definite engine speeds.

Aretz, H. Wan läuft ein Motor schwingungsfrei? Autom. Tech. Zeit., v. 33, no. 10, April 10, 1930. p. 245-249. (figures)

Discussion of the problem of an internal combustion engine running without vibration. It is shown that rotating movement of a body is nothing more than motion consisting of two sinusoidal oscillations, one oscillation being in ratio of 90 degrees and a quarter of period to the other, the whole period representing the total to-and-fro movement of the oscillating point. Classification of pulsating forces into those of first, second, and higher degrees.

Behrens, H. Die Berechnung erzwungener Drehschwingungen Mehrmassensystemen mit besonderer Berücksichtigung der Verhältnisse bei Motorenanlagen. Z.F.M., v. 21, no. 12, June 28, 1930. p. 297-305. (figures, equations)

General formulae derived for reduction to a single equivalent mass and moment of a system with arbitrary number of masses and moments. Particular expressions written down for systems of 2, 3, 4 and 5 masses. Numerical example is worked out for the case of 5 masses. Simplifications introduced for various types of symmetry. Numerical example for ten cylinder engine computed. Results given graphically.

Benz, W. Beitrag zur Berechnung der Drehschwingungszahlen von Mehrzylindermaschinen. Autom. Tech. Zeit., v. 33, no. 27, Sept. 30, 1930. p. 648-650. (figures)

Simplified methods for determining the vibration period of first and second order system; multi-cylinder engine and one mass, respectively, multi-cylinder engine and two masses by means of one chart. Practical example given.

Brandt, H. A. Der Kolbenseitendruck als Ursache von Erschütterungen raschlaufender Verbrennungsmaschinen. Praktische Maschinen-Konstrukteur, v. 63, no. 10, May 25, 1930. p. 210-213; no. 11, June 10. p. 226-229. (figure)

Calculation of side thrust as a function of crank angle and number of revolutions for one and more cylinder engines. The effect of combustion pressure on side thrust is investigated and illustrated by graphs.

Dashefsky, G. J. The Elimination of Torsional Vibration. A.S.M.E. Preprint for meeting, June 12 to June 14, 1930. 7 p. (figures)

Methods of calculating torsional critical speeds and their amplitudes of vibration; original set of tables to facilitate calculation. Expedients for obviating danger from critical speeds; vibration characteristics of double-acting engine; combined, harmonic coefficients for double-acting engine; system of synchronous shafting and methods for neutralization of harmonic torques devised by the author.

Föppl, O. Schwingungsdämpfer für Kurbelwellen. Ingenieur Arch., v. 1, no. 2, March 1930. p. 223-231. (figures, tables, references)

Also Forschungsarbeiten aus dem Gebiete des Ingenieurwesens, v. 2, no. 4, April 1931. p. 124-128.
Schweizerische Bauzeitung, v. 97, no. 21, May 23, 1931. p. 261-263.
Z.V.D.I., v. 75, no. 32, Aug. 8, 1931. p. 1028-1029.

Mathematical outline of the theory underlying the design of vibration dampers for crankshafts with and without resonance. Discussion leads to the conclusion that vibration dampers designed on the basis of resonance principle are preferable.

Lieberherr, H. Bestimmung der Eigenfrequenz von Drehschwingungen. Schweizerische Bauzeitung, v. 95, no. 5, Feb. 1, 1930. p. 61-63. (figures, equations)

Theoretical mathematical discussion of transverse vibrations of shafts of engines.

Schlaefke, K. Zur Bestimmung der Eigenschwingungszahlen von Kurbelwellen. Z.V.D.I., v. 74, no. 42, Oct. 18, 1930. p. 1451-1453. (figures)

Method of calculating the natural vibration period of crankshaft with added mass at front end. Graph illustrated the effect of added mass.

Späth, W. Auswuchttechnik und Schwingungsbekämpfung im Motorenbau. Autom. Tech. Zeit., v. 33, no. 28, Oct. 10, 1930. p. 671-675. (figures)

Description of a method of balancing of crankshafts with three bearings. Satisfactory results obtained only if each throw of the crankshaft is separately balanced, taking into account the effective mass of the connecting rod.

Vollmar, M. Beitrag zur Berechnung von Drehschwingungen und Dämpfung. Tech. Mech. und Thermodynamik, v. 1, no. 11, Nov. 1930. p. 382-391. (figures, tables, equations)

A simplified method for the calculation of the torsional oscillations of crankshafts developed. In the same calculation, consideration is given to the exciting moments and damping. Additional dampers are also studied.

______________ Vibration and Its Isolation. Engineer, v. 152, no. 3953, Oct. 16, 1931. p. 418. (figures)

Results obtained with the help of vibrograph, an instrument made by the Cambridge Instrument Co. Great improvement is effected in isolated foundation design by invention by

Grey of foundation block isolated springs. As applied to oil engines it consists of combined raft and outer shell and main foundation block to which engine is fixed.

Behrens, H. Bestimmung der Drehschwingungszahlen von Motorenanlagen. Autom. Tech. Zeit., v. 34, no. 16, June 10, 1931. p. 376-378. (figures)

Graphical method for direct determination of torsional vibration period of engine with one or two rotating masses. Period of engine with two masses can be determined satisfactorily by approximating method.

Grammel, R. Ein neues Verfahren zur Berechnung der Drehschwingungszahlen von Kurbelwellen. Ingenieur Arch., v. 2, no. 2, May 1931. p. 228-244. (figures, tables, equations, references)

There is no difficulty in determining the dangerous frequencies of the torsional oscillations of crankshafts of few cylinders, but calculation is almost impossible if one wants to know the frequency of an 11 order, ten-cylinder engine with a flywheel and a rotor of a dynamo. General theory of the torsional frequencies of systems.

Heldt, P. M. Torsional Vibrations in V-Engines. Automotive Industries, v. 65, no. 4, July 25, 1931. p. 118-120. (figures)

Some recent V-engines have been laid out with a smaller angle between cylinder banks, partly to reduce their width and partly for manufacturing convenience. This gives an uneven sequence of explosions, resulting in a change in the torsional vibration characteristics of the engine on the one hand and in a less nearly uniform torque curve on the other. This article investigates the effect of an uneven sequence of explosions on the torsional vibration characteristics in some detail.

Kluge, F. Zur Ermittlung kritischer Drehzahlen von Kurbelwellen. Ingenieur Arch., v. 2, no. 2, May 1931. p. 119-139. (figures, tables, equations, references)

Explanation of the phenomenon of resonance due to the torsional oscillations at critical r.p.m. Method used is the classical one, that is, that the experiments are performed on discs rotating uniformly with the crankshaft. A system of differential-linear equations of the second order are obtained. Problem of determining critical velocities considered.

Kobayashi, A. Analytical Study of Crank Efforts in Reciprocating Engines. Ryòjun College of Eng'g.(Manchuria)-Memoirs, v. 4, no. 3, Aug. 1931. p. 127-183. (figures)

Analytical procedure adopted gives directly expressions for unbalanced forces and crank effort without neglecting speed fluctuation. Such expressions are indispencable for computing, for example, torsional vibration of flexible shaft, especially in case of multi-cylinder engines.

Mancy, J. Théorie des Oscillations de Torsion des Lignes d'Arbres de Moteurs à Combustion Interne. Technique du Bureau Veritas-Bul., v. 13, no. 8, Aug. 1931. p. 156-159.

Discussion of the theory of torsional vibrations of internal combustion engine shafting. Oscillations of shaft subjected to external periodic forces. Calculations of amplitude of oscillation. Application of theory of oscillations.

Ormondroyd, J. Problem of Torsional Vibration Increases with Engine Power. Machine Design, v. 3, no. 6, June 1931. p. 37-40. (figures, tables, equations) .

Design requirements for avoiding critical speeds given. Physical basis of calculations; elastic-inertia torque balance frequency; values for elastic curve and natural frequency.

Porter, F. P. A Simple Method for the Calculation of Natural Frequencies of Torsional Vibration. A.S.M.E.-Trans., v. 53, OGP 53-2, 1931. p. 17-46. (figures, tables, references, discussion, bibliography)
Also Z.V.D.I., v. 75, no. 13, March 28, 1931. p. 404-405.

The calculation of the torsional vibration characteristics of the shafting of reciprocating-engine installations, is generally considered a laborious undertaking. This paper presents a method for calculating the natural frequencies of the shafting that is relatively simple in its application and yet retains the accuracy of the longer methods. The simplification is obtained by the proper choice of the equivalent system for mathematical treatment and by use of tables and charts. The accuracy of the results has been compared with that of the results of other investigations.

Roos, D. G. Crankshaft-Vibration Dampers. S.A.E. Meeting Paper, 1931.

Lanchester dampers and dampers of other types discussed, one of them being the rubber-mounted type. In several cars the harmonic type of balancer has been combined with the Lanchester type with good results. Improvements were attempted on the Lanchester damper by adding centrifugal control. Advantages claimed for greater number of bearings in an engine.

Senger, W. I. Obviating Mechanical Troubles by Balancing of Parts. Machine Design, v. 3, no. 1, Jan. 1931. p. 29-32, 78. (figures)

Principles of balancing in cylinders and crankshafts, and design of balancing machine discussed. Charts showing centrifugal force exerted by unbalance at various speeds. Types of vibration which balancing machines cannot eliminate are given. Static and dynamic unbalance explained. Static and dynamic balancing machines are described together with their operation.

Schlaefke, K. Der Einfluss des Arbeitsverfahren von Verbrennungskraftmaschinen auf die Drehschwingungen der Kurbelwellen. Autom. Tech. Zeit., v. 34, no. 33, Nov. 30, 1931. p. 759-760;no. 34-35, Dec. 15. p. 781-783.

Comparison between carburetor engines and direct injection engines made by means of graphical representation of indicated pressure and direct variation. Harmonics are shown graphically and show that direct injection engine suffers more from torsional resonance on the fifth harmonic. Below the corresponding speed there is not sufficient difference between the two types of engine. Harmonics are plotted for six different orders of firing.

Tuplin, W. A. Torsional Flexibility in Gear Drives. Engineering, v. 131, no. 3391, Jan. 9. 1931. p. 37-39; no. 3393, Jan. 23. p. 101-104. (figures, table, equations)

Conditions under which torque variations are reduced by shaft flexibility are investigated. Application of the principles investigated illustrated by numerical example of reciprocating engine drive. Procedure to be adopted in designing flexible shaft drive.

Biot, M. Critical Torsional Oscillations of a Rotating Accelerated Shaft. Nat'l. Acad. Science-Proc., v. 18, no. 12, Dec. 1932. p. 682-689. (equations)
Also Guggenheim Laboratory (Pasadena) Rep. No. 25a.

Calculation of acceleration required to cross certain critical speed, keeping oscillation amplitudes below the given limit. Solution for special case of undamped torsional vibrations with application to crankshaft of 6-cylinder two cycle engine.

Gradstein, S. Erzwungene Torsionsschwingungen von Kurbelwellen. Ingenieur Arch., v. 3, no. 2, May 1932. p. 206-214. (figures, tables, references)

Calculation of the forced torsional vibration of crankshafts. Phase differences are considered for multi-cylinder engines. Tangential forces are analyzed by the Fourier series. Critical r.p.m. are dealt with and without considering the mass of the shaft.

Grammel, R. Die erzwungenen Drehschwingungen von Kurbelwellen. Ingenieur Arch., v. 3, no. 1, March 1932. p. 76-88. (figures)

Methods developed for free and forced torsional vibrations for crankshafts and final formulae given which can be evaluated from tables.

Grammel, R. Die Berechnung der Drehschwingungen von Kurbelwellen mittels der Frequenzfunktionen-Tafel. Ingenieur Arch., v. 3, no. 3, June 1932. p. 277-297. (figures, tables)

In order to make use of the method of calculating torsional vibrations of crankshafts (given in previous paper) convenient, the formulae are applied to 19 machine types. Formulae verified and composed into new frequency table. Calculations are performed for free and forced vibrations. The formulae are reduced by using recursion formulae.

Rembold, V. and Jehlicka, J. Resonanzausschläge bei Drehschwingungen von Kurbelwellen. Z.V.D.I., v. 76, no. 20, May 14, 1932. p. 480-482. (figures, tables)

The equation of forced vibrations for the system of crankshaft plus pistons is established and verified on a model by the Geiger oscillograph. Effect of gas forces is shown approximately by fitting springs above the pistons. Model also allows such effects as bearing clearance and orientation of the crank throws to be studied.

Bonnier, C. and Thaler, L. Etude des Vibrations de Torsion des Arbres des Machines. Science et Industrie, v. 17, no. 228, Jan. 1933. p. 1-4; no. 229, Feb. p. 73-76; no. 230, March. p. 115-120; no. 231, April. p. 178-181; no. 233, June. p. 257-262. (bibliography)

Mathematical analysis of the principal factors controlling torsional vibrations in shafts and shafting, including crankshafts; calculation of critical speeds with numerical example. Study of torsional vibrations in machine shafts. Calculation of fatigue; decomposition of periodical function in Fourier series; practical calculation of natural frequency of oscillation of line, shaft, etc. Notes on the determination of critical speeds and relative importance. Description of the D.V.L. torsiograph.

Dick, J. Surging in Helical Valve Springs. Roy. Aero. Soc.-Jl., v. 37, no. 271, July 1933. p. 641-654. (appendix)

High-speed internal combustion engine presents many problems arising from dynamic effects among which is the phenomenon known as "surging" in the helical spring used for the operation of the valves, which leads to increased stresses and thereby contributes to spring fractures. Theoretical treatment of the distribution of surge stress with suggestions for methods of minimizing the effect of these stresses. Estimation of the frequency of vibration of the spring. Factors in the spring affecting damping, reflection and resonance of surge wave.

Klüsener, O. Biegungsschwingungen zweimal gelagerter Kurbelwellen. Autom. Tech. Zeit., v. 36, no. 3, Feb. 10, 1933. p. 53-54. (figures)

Pressure exerted on a piston by exploding charge and the inertia forces of the reciprocating mass cause deflections of the crankshafts which vary continually in direction and magnitude. If these impulses are in resonance with the natural frequency of vibration of the crankshaft, disastrous results may follow. Research on this subject raised the question whether only speeds which coincide with the natural frequency should be considered as critical, or whether bending vibrations may be induced at other speeds also. Example given of calculation and test of bending vibrations in a crankshaft mounted on two bearings.

Kuchenmeister, W. and Vickery, F. W. A. Balancing. Inst. Product Engrs. Meeting Paper, 1933.

Description of a flywheel balancing machine, crankshaft balancing machine and an aero engine balancing machine.

Nixon, F. The Design of Valve Springs. Aircraft Engineering, v. 5, no. 55, Sept. 1933. p. 193-196. (figures, tables, references)

Briefly outlines the salient points affecting the design of valve springs. Discussion given of surge as caused by resonance. Methods suggested for reducing surge, damping by means of spring fingers, frictional damping, variation of natural frequency of the spring. Selection of materials used in valve springs important. Fatique limits and stresses in valve springs given in diagrams. Formulae for design of valve springs also given.

Normand, A. A. Au Sujet des Vibrations de Torsion des Lignes d'Arbres Entrainées par un Moteur à Combustion Interne. Technique du Bureau Veritas-Bul., v. 15, no. 11, Nov. 1933. p. 213-216.

Torsional vibrations of shafts driven by internal combustion engine. Results of tests on shafts driven by two cycle, single-acting 9-cylinder, Diesel engines of 3600 h.p.

Scheuermeyer, M. Unregelmässige Zündfolge und Drehschwingungen bei Verbrennungsmotoren. Werft-Raederei-Hafen, v. 14, no. 5, March 1, 1933. p. 59-61.
Also Marine Engineering, v. 56, no. 667, April 1933. p. 129.

Discussion of irregular firing and torsional oscillation. Fourier series are formed to express the periodic torques; vector diagrams are drawn and resulting torque variations are tabulated and shown graphically.

Scheuermeyer, M. Einfluss der Zündfolge auf die Drehschwingungen von Reihenmotoren. Autom. Tech. Zeit., v. 36, no. 16, Aug. 25, 1933. p. 401-404; no. 17, Sept. 10, p. 431-433. (figures, references)

Discussion of the influence of firing order on the torsional vibration of in-line engines. In the usual calculation for vibration frequency, one half of reciprocating masses is assumed to participate in the vibration. The assumption leads to a mean frequency. Actually, the varying acceleration of the masses imposes considerable variation in frequency during a revolution. The author shows how these variations can be minimized by altering firing order. Secondary harmonics can be eliminated, but the principal harmonics operate over an increased range.

______________ Absorption of Oscillations in Engine Shafts. Commercial Motor, May 11, 1934. p. 450. (figures)

An invention which may have considerable bearing upon engine design has reached commercial stage in France. The aim is to absorb, or filter out all parasitic oscillations from an engine shaft and provide an absolutely constant couple, even in case of single cylindered engine.

Benz, W. Beitrag zur Berechnung der Drehschwingungszahlen von Mehrzylindermaschinen. Autom. Tech. Zeit., v. 37, no. 5, March 10, 1934. p. 124.

Calculation of torsional vibration of multiple-cylinder engines supplementing an article in Engineering, Sept. 30, 1930, p. 475. An alignment chart is presented which combines two charts previously given and which can be very simply and rapidly used.

Ekserjian, R. Dynamics of Engines on Elastic Suspension. Four Inter. Cong. Appl. Mech.-Proc., July 1934.

Primary object of elastic suspension of engine mounts is to reduce vibration reactions transmitted to foundation resulting from disturbing forces, such as torque reaction variations, unbalance, etc. In this paper, consideration is given to the nature of the primary disturbing forces, together with an analysis of the vibration characteristics with different types of suspensions. For instance, suspension configurations for eliminating lateral and nosing vibrations and a study of a frame vibration absorber have been made. A system of equations was developed for calculating the interaction within the system resulting from the flexibility of the supension and the torsional flexibility of the crankshaft. In calculating the vibration frequencies for the latter case, two attacks have been made. Since an engine system elastically suspended offers, in addition to its practical applications, an interesting dynamical system of several degrees of freedom, a generalization of the analysis has been made with interpretations of the interactions involved as a procedure for similar mechanical systems.

Geiger, J. Dämpfung bei Drehschwingungen von Motoren. Z.V.D.I., v. 78, no. 46, Nov. 17, 1934. p. 1353-1355. (figures, tables, references)

In the absence of an external damper, torsional oscillations of engines are damped by mechanical and aerodynamical friction, and by elastic hysteresis, mainly in the shaft. With mild resonance, the more important damping terms are due to friction, with severe resonance, to hysteresis.

Geiger, J. Die Dämpfung bei Drehschwingungen von Brennkraftmaschinen. Mitteilungen aus den Forschungsanstalten, Anst. G.H.H. Konzern, v. 3, no. 6, Dec. 1934. p. 147-165. (figures, equations references)
Also Autom. Tech. Zeit., v. 38, no. 14, July 25, 1935. p. 366-367.
Automotive Industries, v. 73, no. 8, Aug. 24, 1935. p. 238-239.

Discussion of the damping of torsional oscillations in internal combustion engines. It is shown that the use of mean damping factor for internal combustion engines leads to incorrect results. Investigation of different apparent and actual damping processes, most important of which is claimed to be hysteresis.

Grammel, R. Die Drehschwingungen der Blockmotoren. Ingenieur Arch., v. 5, no. 2, April 1934. p. 83-91. (figures, equations, references)

Discussion of torsional oscillations of engines with cylinders in line. The usual recursion formula is obtained by a simplified method and applied to a variety of cases with additional rotating masses. The frequency formulae are established in simple forms with sufficient accuracy for design calculations. Further extended applications are indicated.

Klotter, K. Kupplung mechanischer Schwingungen. Ingenieur Arch., v. 5, no. 3, June 1934. p. 157-163. (figures)

Two systems of coupled mechanical vibrations are established.

Kluge, F. Bestimmung kritischer Drehschwingungszahlen durch Versuch und Rechnung. Forschung aus dem Gebiete des Ingenieurwesens, v. 5, no. 6, Nov.-Dec. 1934. p. 260-265. (figures)
Also Z.V.D.I., v. 79, no. 19, May 11, 1935. p. 591-592.

Experimental and numerical determination of critical frequencies of torsional vibrations. Investigations were made of single-crank machine with a flywheel. Results show agreement with those obtained by taking reciprocating masses into consideration, but disagreement with the classic method of calculating torsional vibration and critical speeds of crankshafts, as postulated by H. Holzer in 1921.

Lutz, O. The Processes in Spring-Loaded Injection Valves of Solid Injection Oil Engines. N.A.C.A., Tech. Mem. No. 758, Nov. 1934. 23 p. (figures, references)
Translated from Ingenieur Arch., v. 4, no. 2, 1933. p. 153-168.

Development and theoretical analysis of the equation of motion of a spring-loaded valve stem. It was found that the stem oscillated, the oscillation frequency being consistently above the natural frequency of the nozzle stem alone, and whose amplitudes would increase in the absence of damping.

Schlaefke, K. Bewegungsverhältnisse von Kurbelgetrieben mit Nebenpleuelstangen. Z.V.D.I., v. 78, no. 27, July 7, 1934. p. 831-834. (figures)

The auxiliary rod assembly involves a displacement of the dead center position and a change in stroke of the corresponding auxiliary piston, which may affect the torsional vibration characteristics of the complete engine.

Wassutinsky, S. Vibrations de Torsion des Arbres Vilebrequins et leurs Vitesses de Résonance. Tech. Autom. et Aérienne, v. 25, no. 167, 1934. p. 97-101. (figures, tables, equations)
Torsional vibration of crankshaft and their resonant speeds. This article is based on studies by ... Blondel. Theoretical mathematical design analysis with design data in tables and curves.

Grammel, R. Die kritischen Drehzahlen bei Kolbenmotoren. Z.A.M.M., v. 15, no. 1-2, Feb. 1935. p. 47-51. (equations references)

Description of classical method of calculation of torsional vibration of crankshafts by using a table of frequency functions.

Johnson, W. E. A Method of Balancing Reciprocating Machines. A.S.M.E.-Trans., v. 57, Appl. Mech. 1935. p. A81-A86. (appendix, figures, equations)
Discussion v. 58, 1936. p. A34-A36.

General types of balancing problems are classified into three groups: those requiring perfect balance, those in which the machine inherently is balanced sufficiently well for practical purposes, and those requiring a distinct compromise, such as single-cylinder engines. It is a method of securing an optimum condition for the last class that is presented. The problem to be solved here is that of obtaining an optimum balance for a simple compressor with a vertical, overhung crankshaft. For purposes of illustration, the optimum will be obtained for each of several criteria.

Schmidt, E. Schwingungen grosser Amplitude von Gassäulen in Rohrleitungen. Z.V.D.I., v. 79, no. 22, June 1, 1935. p. 671-673. (figures, references)

Experimental study of vibrations of great amplitude in gas columns in pipe lines, such as occur in exhaust piping of internal combustion engines. Resonance phenomena.

Shannon, J. F. Damping Influence in Torsional Oscillation. Inst. Mech. Engrs (London)-Proc., v. 131, Dec. 1935. p. 387-492. (figures, tables, equations, references, bibliography, discussion)
Also Engineering, v. 140, no. 3649, Dec. 20, 1935. p. 675-678; no. 3650, Dec. 27. p. 702-704.

Investigation of nature and distribution of damping influences in engine torsional oscillation, and factors controlling amplitude at resonance, on small-scale plant so that the effects of mass, frequency, and amplitude could be examined together with lubrication and piston ring effects. Experiments carried out mainly on 4-cylinder gasoline engine, employing Geiger torsiograph.

Sparrow, S. W. Problems in the Development of a High-Speed Engine. S.A.E.-Jl.(Trans.), v. 36, no. 2, Feb. 1935. p. 58-39. (figures)

The engine considered in this paper is an eight-in-line of 3 1/16" bore, and 4 1/4" stroke, having a piston displacement of 250 cu. in. The paper includes a discussion of crankshaft failures as the result of torsional vibration of the crankshaft due to inadequate vibration damping. Table showing torsional periods at the speeds indicated in the absence of damping. Two types of vibration dampers, the oscillating and rotating, are discussed.

Wassutinsky, S. Vibrations de Torsion et Vitesses Critiques de Résonance des Arbres Munis d'Accouplements Elastiques. Tech. Autom. et Aérienne, v. 26, no. 171, 1935. p. 115-118. (figures, tables)

Theoretical, mathematical study pertaining to torsional vibrations and critical resonance speeds of a shaft provided with elastic couplings. Various equations for calculations tabulated. Tables of constants.

Appendrodt, A. Dämpfungsfähigkeit von Kurbelwellenstählen. Z.V.D.I., v. 80, no. 17, April 25, 1936. p. 517-518. (figures)

The damping power of crankshaft steels measured on a Föppl-Pertz vibration machine, readings being taken for the material as received and after 50,000; 200,000; $1.25x10^6$; $6.25x10^6$; and $31.25x10^6$ reversals. The damping capacity varies with the composition of the steel. Least damping-tempered Cr-Ni-T steel. Highest damping by Siemens Martin St. 42-11. Damping alters with the number of reversals, but usually settles down to a steady value after $6x10^6$ reversals, provided no previous fracture takes place.

Behrmann, W. Ermittlung der Dreheigenschwingungszahlen und formen mehrzlindriger, mit zwei Massen gekuppelter Reihenmotoren. Werft-Raederei-Hafen, v. 17, no. 4, Feb. 15, 1936. p. 41-43.

Determination of natural torsional vibration coefficients and forms of multi-cylinder engines coupled with two masses. Method developed by H. Behrens and conditions governing its application to engines consisting of two masses. Examples given.

Dick, J. Pendulum Torsional Vibration Absorber. Engineer, v. 162, no. 4221, Dec. 4, 1936. p. 595.

Vibration absorber, introduced in America, is suitable for neutralizing disturbing harmonic torques of any frequency which is given multiple of r.p.m. of engine.

Labarthe, A. and Vichniewsky, R. Etude de la Période du Phénomène Vibratoire Accompagnant la Combustion dans les Moteurs à Explosion. Inst. de France, Acad. des Sciences, Comptes Rendus, v. 202, no. 8, Feb. 24, 1936. p. 631-634.

Photographic recording of pressure-time diagrams taken by the photocathodic method. On parts of the diagrams corresponding to the combustion process the existence of a vibratory phenomenon having a frequency of the order of 2000 periods per second was discovered. The amplitude of these vibrations which are superimposed on the variations of pressure due to the combustion never exceeds, under ordinary conditions, 4 to 5% of the maximum pressure. Very much greater amplitudes of vibration can be obtained, however, if the compression ratio is exceeded or highly detonating fuels are employed.

Labarthe, A., Vichniewsky, R. and Manson Sur la Nature des Phénomènes Vibratoires dus à Certaines Combustions du Fluide Evoluant dans un Moteur Thermique. Inst. de France, Acad. des Sciences, Comptes Rendus, v. 202, no. 19, May 11, 1936. p. 1566-1568. (figures)

Discussion of vibration phenomena during combustion in an engine cylinder. Records taken by cathode ray indicator on a C.F.R. engine show presence of a fundamental vibration of frequency of 2300 per sec., together with secondary vibrations of higher frequency. Fundamental frequency is unaffected by piston position or engine speed, but apparently depends on the engine bore. Secondary vibrations vary in frequency during the stroke, having a maximum of approximately 16,000 per sec. at T.D.C. and falling to 3000 per sec. at the end of expansion. These vibrations are heavily damped and are probably due to waves along the cylinder axis.

Lieberherr, H. Graphische Bestimmung der Eigenfrequenz von Drehschwingungen. Schweizerische Bauzeitung, v. 107, no. 26, June 27, 1936. p. 289-291. (figures, equations)

A graphical method for determination of period of torsional vibrations given.

Mayer-Schuchard, C. Schwingungen von Luftsäulen mit grosser Amplitude. Forschungsheft 376, v. 7, Jan.-Feb. 1936. p. 13-22.

Oscillations of air columns with great amplitude such as occur in pumps and exhaust pipe of internal combustion engines. Report of experiments carried out in machine laboratory of Danzig Institute of Technology on air column oscillating in pipe line, oscillation being produced by piston of 2 cylinder BMW engine driven by a DC motor.

Neugebauer, F. Die Baustoffdämpfung in den Wellen leichter Triebwerke. L.F.F., v. 13, no. 2, Feb. 20, 1936. p.57-60. (figures, equations, bibliography)

The object of the investigation is to ascertain whether shafting of light power plants can be adequately protected against failure due to rotational oscillations by damping of material of construction. Special attention paid to the fact that such shafting frequently incorporates toothed wheel gearing. Sufficiently high materials damping involves high stresses in material, which set up high alternating moments acting deleteriously on other parts of the power plant. Final conclusion is that metals used in construction must be rendered, to a considerably higher degree, more amenable to damping.

Polak, - Tlumienie drgan skretnych walow korbowych. Przeglad Mechaniczny, v. 11, no. 6, March 25, 1936. p. 156-160; no. 8, April 25. p. 248-252; no. 9, May 10. p. 290-294. (figures, tables, bibliography) (In Polish with brief French abstract)

Discussion of the phenomenon of torsional vibrations and its causes. Critical speeds and danger of resonance in different types of internal combustion engines discussed. Damping of torsional vibrations in single-stroke crankshafts of internal combustion engines. Determination of various vibration factors and combatment.

Rosenzweig, S. Vibration Control of Internal Combustion Engines. A.S.M.E. Meeting Paper, June 25, 1936. 12 p.

Discussion of the need of protection against transmission of machine vibrations and outline of laws governing their control. Various isolating materials discussed with relative advantages and applications in actual use. Materials cover natural cork in plates and in unit housing devices, steel springs, their functions and applications to machines with and without concrete foundations. Important court decisions cited which emphasize necessity of controlling vibrations.

Schlaefke, K. Der Einfluss des V-Winkels auf die Kurbelwellen-Drehschwingungen von V-Motoren. Z.V.D.I., v. 80, no. 41, Oct. 10, 1936. p. 1253-1254. (figures)

Influence of V-angle on torsional vibration of crankshaft of V-engines. It is shown that actual interrelation exists and that for 8 and 12 cylinder engines the most favorable value of angle is found by analysis as given. Example.

Tricomi, F. Sulle Vibrazioni Transversali di Aste, Specialmente di Bielle, di Sezione Variabile. Ricerche di Ingeneria, v. 4, no. 2, March-April 1936. p. 47-53.

Theoretical mathematical analysis of transverse vibrations of rods, particularly connecting rods, of variable cross-section.

Tuplin, W. A. Transient Torsional Vibrations. Engineering, v. 141, no. 3656, Feb. 7, 1936. p. 154-156; no. 3659, Feb. 28, 1936. p. 221-222. (figures, references, equations)

Stresses associated with transient torsional vibrations in an internal combustion engine. A dynamical system is described which consists of two heavy rotors connected by a single shaft. A drive, which gives critical speeds of low order below the running range, can be represented by such a system, and the transient vibration stress figures can be obtained in a reasonably accurate way. Formulae for calculating vibration stresses and a method for determining the maximum amplitude of vibration in accelerating past the critical speed given. Typical examples given.

Tuplin, W. A. The Effect of Changes in a Torsionally Vibrating System on the Natural Frequencies of the System. Phil. Mag., S. 7, v. 21, no. 144, June 1936. p. 1097-1111. (figures, equations)

In engine installation, the normal procedure is to design the plant and calculate vibration characteristics afterwards. If troublesome criticals are found within running range, attempt is then made to alter the frequency by adjusting the inertia or torsional stiffeners. Effects of alteration are shown, if adjustment is applied equally to every member of the system. If various elements are altered in a different degree, a recalculation of the vibration characteristics is required. This article shows how complete recalculation can be saved in case of small changes. The effect on frequency estimated from shape of original elastic curve.

___________________ Valve-Gear Vibration. Studies with Cathode Ray Oscillograph. Automobile Engineer, v. 27, no. 360, July 1937. p. 246. (figure)

Some observations on valve-gear vibration which were based on experiments carried out with a cathode ray oscillograph for which special devices were developed. Conclusion is that valve gears contribute a large part of all engine noise at high speed.

Marti, W. Valve Spring Surge. N.A.C.A. Tech. Mem. No. 813, March 1937. 34 p. (figures, references, equations, bibliography)
Translated from Eidgenössichen Technischen Hochschule in Zurich, 1935. p. 1-20.

Results of experimental study of oscillations with special reference to injection valves of Diesel engines. Theory of waves in valve springs. Computation of amplitude of oscillation for single lift by harmonic analysis. Effect of cam profile. Forced spring oscillation with damping. Free vibration and effect of play between cam and follower.

# VIBRATION STUDIES IN ALLIED FIELDS - MACHINERY.

Cutler, C. W. Uniform Methods of Calculating the Periodic Displacement and Oscillations in Synchronous Machines. A.S.M.E., Meeting Paper (San Francisco), June 28-July 1, 1926.

Paper forms a basis for the design of flywheels for engine-driven generators operating in parallel, the present rules applying only in case of operation against an infinite system. Develops a method whereby power exchange, torque variations and other phenomena can be accurately obtained. General solution for two engine-driven generators by means of a nomographic chart given in an appendix, also method of constructing the chart.

Rausch, E. Maschinenfundamente. Bauingenieur, v. 7, no. 44, Oct. 29, 1926. p. 859-863; no. 45, Nov. 5. p. 877-882. (figures)

Discusses mass of foundations, derivations of formulae for vertical and longitudinal vibrations, movements of foundations and their causes, turbine foundations, effect of steam pipe lines, calculation of forces in masses in rotation, reciprocation or impact motion, advantages of rigid foundations, admissible stresses in cases of periodic loading.

Speiser, W. Isolierung gegen Geräusche und Erschütterungen. Dingler's Polytechnisches-Jl., v. 341, no. 11, June 1926. p. 117-120. (figures)

Discusses insulating properties of cork and use of "Korfund" sheets of cork wood in iron frames for foundations of various machines to eliminate vibration, also resulting in smoother running.

Prager, W. Die Berechnung der Eigenschwingungen von Rahmenfundamenten. Bauingenieur, v. 8, no. 8, Feb. 19, 1927. p. 129-131. (figures)

Derives theoretical formulae and gives curves for evaluating the factors needed in calculating the period of vibration of frame foundations of turbines and other machinery.

Den Hartog, J. P. Vibration of Frames of Electrical Machines. A.S.M.E.-Trans., v. 50, APM 50-6, 1928. p. 1-6. (appendix, figures, discussion)

In connection with the attempts to reduce the noise of electrical machinery in general, and more especially of small motors for domestic use, it is of importance to be able to calculate the natural frequency of vibration. It is shown that the frame which usually emits a large portion of the total noise, can in many cases, be regarded as a part of a ring with rigid ends. Formulae and curves are given in the paper for the calculation of the fundamental frequency. The derivation of these formulae is given in an appendix.

Den Hartog, J. P. Vibration of Frames of Electrical Machines. A.S.M.E.-Trans., v. 50, APM 50-11, 1928. p. 9-11. (figures)

Paper gives a formula and curves for the calculation of the natural frequency of frames with a consideration of the flexibility of the feet. As an illustration, an example met in practice is discussed in detail.

Kammerer, F. Der Betrieb und die Instandhaltung von Wasserkraftanlagen. Zeit. des Bayerischer Revisions-Verein, v. 32, no. 7, April 15, 1928. p. 77-80, no. 9, May p. 109-112. (figures, bibliography)

General analysis of factors in operation of hydroelectric plants; silting, cavitation of turbine parts, resonance vibrations in machinery and other causes interfering with operation. General rules of operation and maintenance.

Stone, M. Stress Analysis in Electrical Rotating Machinery. A.S.M.E.-Trans., v. 50, APM 50-16, 1928. p. 57-79. (appendices, figures, references, discussion)

Author's discussion covers principally the analysis of stresses in electrical machinery. Other main groups of mechanical problems concerning vibration and balancing of generators and motors are briefly dealt with in early part of paper.

________________ Maschinen- und Fundamentschwingungen. Elektrizitaetswirtschaft, v. 28, no. 492, Sept. 1929. p. 486-488.

Brief review of causes and remedies of vibration in large machinery of any kind in modern practice. Short notes on papers read before special convention of the Verein Deutscher Elektrizitaetswerke.

Mueller, P. Schwingungen von Fundamenten Rotierender Maschinen. Bauingenieur, v. 10, no. 13, March 29, 1929. p. 228-234. (figures, references)

Comparison of the results of model tests with theoretical determination. Constrained vibrations of coupled systems. Constrained vibrations in ground and in uniformly homogeneous elastic material.

______________ "Keldur" Vibration-Insulating and Sound-Proofing Material. American Machinist, v. 72, no. 19, May 8, 1930. p. 783.

Resilient, rubber-like material, held between layers of coarsely woven jute cloth or burlap, tends to deaden noise and check vibration and is not subject to deterioration in presence of oil and will not harden. Possesses durability against mechanical and chemical disturbances and will retain elasticity almost indefinitely. It can be used for either light or heavy equipment such as drop hammers, motors and generators, etc.

Crespo, R. Sobre el Empleo de Materiales Amortiguadores de la Vibraciones en la Cimentacion de Máquinas. Ingenieria Naval, v. 2, no. 6, Feb. 1930. p. 49-55. (figures)

Use of vibration-damping material in machinery foundations discussed.

Nölle, -. Der heutige Stand der Forschungen auf dem Gebiete der Maschinen- und Fundamentschwingungen. Archiv für Waermewirtschaft und Dampfkesselwessen, v. 11, no. 6, June 1930. p. 207-210. (figures)

Study is based on the works of Blaess, Geiger, Beyer, Ehlers, Hort, Rausch, Nölle, Reuter, Lupberger, Zeuner and Marguerre read before the Vereingung der Elektrizitaetswerke, April 25, 1929, and of Kayser, published in Z.V.D.I., 1929. Critical speed and balancing of rotors; formula for oscillation; determination of vibratory properties of different foundations.

Peterson, R. E. Natural Frequency of Gears. A.S.M.E.-Trans., v. 52, APM 52-1, 1930. p. 1-11. (figures, tables, references, discussion)

Natural frequency of machine parts as related to the noise problem in machine operation discussed in a general manner. Vibration phenomena in discs and rings are described in detail, following which the author discusses the manner in which a gear vibrates at its natural frequency. An empirical formula is given for the natural frequency of a gear in terms of its dimensions and material.

Rice, G. Eliminating Vibration in High Speed Machinery with Rubber Foundations. Rubber Age, v. 28, no. 2, Oct. 25, 1930. p. 85-86. (figures)

A concrete slab on a rubber foundation makes a flooring for high speed machinery that will greatly reduce and often eliminate vibrations usually accompanying heavy machinery. Method of construction and advantages are given.

Timoshenko, S. Recent Developments in the Application of Mechanics to Machine Design. Mechanical Engineering, v. 52, no. 6, June 1930. p. 607-610. (figures, equations, references)

Problems involved in the calculation of natural frequencies of vibration of structures and of critical speeds of rotating machinery are considered.

Eksergian, R. Dynamic Analysis of Machines. Franklin Inst.-Jl., v. 211, no. 3, March 1931. p. 353-380. (figures)

Analysis of mechanisms subjected to common rotation; oscillation of synchronous machine connected with engine mechanism; torsional oscillations in engine shafts; time vector analysis of torsional oscillations.

Fuhrmann, O. Berechnung eines Generatorfundamentes mit stehender Welle. Bauingenieur, v. 12, no. 22-23, May 29, 1931. p. 417-421. (figures)

Detailed design of frame foundation for 27,000 hp. vertical electric generator. Effect of vertical and horizontal vibrations on foundations. Vibration of two-hinge frame under various conditions; critical speed of shaft and short-circuit moment.

Holm, A. R. Svingninger I Maskindele. Ingenioren (Copenhagen), v. 40, no. 28, July 11, 1931. p. 337-346. (figures)

Consideration given to the theoretical aspects of the principal types of vibrations. Harmonic analysis of vibrations in internal combustion engines. Methods of damping.

Hull, E. H. Influence of Damping in the Elastic Mounting of Vibrating Machines. A.S.M.E.-Trans., v. 53, APM 53-12, 1931. p. 155-165. (appendix, figures, equations, references, discussion)
Also Mechanical Engineering, v. 53, no. 11, Nov. 1931. p. 805-809.

Paper considers the elastic material for, and design of, elastic mountings intended for the prevention of transmission of vibration from electrical apparatus into the structure of buildings. It was shown analytically that damping or internal friction in an elastic mounting causes additional transmission through the mounting. An apparatus was built to compare directly the effectiveness of material proposed for elastic support. Drift tests were made to aid in determining the best material for this work. As an example, incorporation of rubber in a mounting for a 15 hp. induction motor is described.

Hull, E. H. and Stewart, W. C. Elastic Supports for Isolating Rotating Machinery. Electrical Engineering, v. 50, no. 5, May 1931. p. 347-349. (figures, reference)

Elastic supports can be made to isolate from two types of disturbance - shocks of any frequency typified by automobile spring suspension, or from vibration of one or several known and constant frequencies. Supports described fall in the second class, the function of these supports being to isolate, not absorb, vibration.

Ogawa, T. Effect of Vibration on Electrical Machinery and Apparatus. Inst. Elec. Engr. (Japan)-Jl., v. 51, no. 1, Jan. 1931. p. 9-10. (In Japanese with English abstract)

Vibrations of high-speed motors are treated, and the phenomena of first and higher order critical speeds are discussed. Torsional vibrations of shaft systems direct-coupled to Diesel engine with one or more armatures; vibration absorbers; effects of vibration and its remedy.

_______________ Develops Device to Eliminate Machine Vibration. Iron Age, v. 130, no. 1, July 7, 1932. p. 14.

Device being developed by T. A. Edison, Inc., Orange, N. J., to eliminate or greatly reduce vibration from mechanisms which are subjected to forces tending to set up such vibration.

Katel, I. La Protection des Fondations des Machines contre les Effets des Vibrations. Génie Civil, v. 100, no. 3, Jan. 16, 1932. p. 67-69. (figures)
Also Concrete and Construction Engineering, v. 27, no. 4, April 1932. p. 228-229.

Principles of design of machine foundations taking into account the effect of vibrations largely based on a paper by E. Rausch in Bauingenieur, v. 7, nos. 44-45, Oct. 29, Nov. 5, 1926. p.859-863; 877-882.

Lewis, F. M. Vibration During Acceleration Through a Critical Speed. A.S.M.E.-Trans., v. 54, APM 54-24, 1932. p. 253-261. (figures, equations, references, discussion)

Gives an exact solution of the problem of running a system having a single degree of freedom and linear damping through its critical speed from rest at a uniform acceleration. An exact expression is found for the envelope in which are located the maximum amplitudes. The results are plotted for various rates of acceleration and for various dampings.

Peineke, W. Dauerbruche durch Drehschwingungen an elektrischen Antrieben. Maschinenbau, v. 11, no. 15, Aug. 4, 1932. p. 313-316. (figures)

Examples of failure of shafts, gears, and fans due to vibrations in shafting of electric drives.

Stone, M. Non-Unilateral Oscillations. Franklin Inst.-Jl., v. 214, no. 6, Dec. 1932. p. 633-646. (figures, equations, references)

Shows the nature of oscillatory phenomena involved in the parallel operation of A.C. generators by governor-controlled prime movers to be either stable or unstable, depending on the magnitude of the various electrical and mechanical quantities in the system. Further, such systems are non-unilateral coupled systems, and thus classify themselves as systems capable of self-induced vibrations.

Turcott, D. B. Torsional Vibration - How to Prevent It. Product Engineering, v. 3, no. 2, Feb. 1932. p. 79-81. (figures, equations)
Also Power, v. 75, no. 9, March 1, 1932. p. 329-331.
Mechanical World, v. 91, no. 2362, April 8, 1932. p. 341-342.

Motors running at high speed and fed from a frequency changer are subject to a vibration which is peculiar to the circumstances. The causes of this vibration, in which critical speed is a major factor, are investigated. Suggestions are made on how the trouble may be avoided.

__________ Lord Plate-Form Vibration Absorption Machine Mountings. American Machinist, v. 77, no. 10, May 10, 1933. p. 320. (figures)

Device to protect instruments and machinery from shock and vibration, made in three designs - square plate, round plate and stamped holder. Rubber is bonded to metallic elements and takes stress in shear. Characteristic is the fact that the mountings are many times as stiff radially as axially. This permits a suspension comparatively stable in any direction, with a low natural frequency in the direction of vibratory thrusts. At the same time, the hysteresis or internal friction of the rubber reduces the amplitude at resonance and damps out repeated oscillations. Description of plate-form mounting.

__________ Floating Power for Machines. American Machinist, v. 78, no. 4, Feb. 14, 1934. p. 146.

A manufacturer has overcome motor vibration by mounting the motor on rubber, driving through V-belts.

__________ Rubber Motor Mounting Proved Effective. Scientific American, v. 151, no. 1, July 1934. p. 34-35. (figure)

Shows the effectiveness in damping out vibrations of the rubber mountings used by General Electric on its latest appliance motors.

Bielitz, F. and Maduschka, L. Mechanische Schwingungen im Maschinenbau. Forschungsheft 368, Sept.-Oct. 1934. 30 p. (figures, tables)

In his first paper, Dr. Bielitz discusses the inversion of linear mechanical vibrating systems, and applies the results to various practical problems of damping the vibrations of machinery. In the second paper, Dr. Maduschka gives a mathematical study of the vibrations of block foundations for machinery.

Brown, F. H. Lateral Vibration of Ring-Shaped Frames. Franklin Inst.-Jl., v. 218, no. 1, July 1934. p. 41-48. (appendix, figures, tables, references)

The frame is regarded as a circular segment of about 320 degrees with encastré ends. An expression is formed for the potential energy of strain and the kinetic energy of vibration, and an approximate result is obtained for the frequency of vibration which is within 3% of the observed values.

Diegmann, H. Vermeidung von Maschinenschäden durch Erschütterungsbekämpfung. Wärme, v. 57, no. 15, April 14, 1934. p. 244. (table)

Brief note on prevention of injury to machinery by vibration absorption. Data concerning efficacy of various forms of cork in preventing transmission of vibration from foundation blocks to ground. Tables given showing the elastic and damping characteristics of natural cork and various compositions.

Grey, R. B. Prevention of Vibration and Noise. Inspection, v. 5, no. 1, Jan. 1934. p. 1-24.
Also Mechanical World, v. 94, no. 2447, Nov. 24, 1933. p. 1124-1125; no. 2448, Dec. 1. p. 1148-1149.

Three classes into which vibration can be divided and into which machinery can be divided for the purpose of isolation. How transmission takes place; foundations; properties which resilient material for isolating foundation should possess; springs; isolating sensitive apparatus; anti-vibration devices; vibrograph instruments; harmonic balancing gear.

Leonhardt, R. W. P. Vibrations in Machinery. Machinery (London), v. 45, no. 1156, Dec. 6, 1934. p. 367-371. (figures)

Causes, effects and methods of elimination of vibrations in machinery.

Popp, P. Beitrag zur experimentellen Untersuchung schwingungsdämpfender Untertagen für Maschinen. Zeit. Tech. Phys., v. 15, no. 10, Oct. 1934. p. 391-397. (figures, references)

Contribution to experimental study of damping pads for vibrating machinery. Theoretical principles and description of experimental arrangement and experiments. Analysis of results showing influence of amplitude of force. Frequency relation of elasticity and absorption pad. Relation between spring effect and adsorption to its surface.

Süss, G. Ausgleich von Drehschwingungen bei Maschinensätzen. Fördertechnik und Frachtverkehr, v. 27, no. 15-16, July 27, 1934. p. 172-174; no. 17-18, Aug. 24. p. 197-199. (figures, equations)

Compensation of torsional vibrations in machinery sets. Discussion of oscillation which may result from unequal degree of irregularity in two coupled machines and suggestions made of various methods by which these vibrations may be compensated.

Thum, A. and Oeser, K. Gummigefederte Maschinen. Z.V.D.I., v. 78, no. 19, May 12, 1934. p. 587-589. (figures, references)

Experiments furnished the elastic and damping coefficients of rubber for the calculation of rubber cylinders, which are used successfully to damp the transmission of vibration and noise from machines through their foundations. The life of a cylinder depends on the quality of the rubber and temperature rise.

Zeller, W. Querschnitt durch den Stand der Schwingungsisolier-Technik bei Maschinen. Maschinen Schaden, v. 11, no. 9, 1934. p. 137-140.

Review of technology of vibration damping of machines. Damping of rotating and percussion machines. Materials and machinery elements employed in damping.

______________ Vibration Eliminator. American Machinist, v. 79, no. 12, June 5, 1935. p. 445. (figure)
Also Machine Design, v. 7, no. 6, June 1935. p. 62-63.

Vibration eliminator introduced consisting of a base stamping and supporting housing to which the base of a machine may be rigidly fastened. Isolating material, natural cork, is not affected by water, oil or temperature changes. Does not take a permanent set under excessive loads.

______________ Coupling Reduces Vibration. Machine Design, v. 7, no. 6, June 1935. p. 63. (figure)

Elimination of the transmission of noise and motor torque vibration from the motor to the driven shaft is the principle on which the drive coupling for fractional horsepower motors being offered by Guardian Utilities Co., Chicago, Ill., is designed. Made of flexible rubber, the coupling, treated to resist the action of oils, is offered in various lengths to eliminate the need for shaft extensions.

Thum, A. and Oeser, K. Rubber Dampeners for Stationary Machines. Material Testing Inst. of the Tech. Hochschule, Darmstadt, Berlin, 1935. (In German)

The use of rubber to dampen the vibrations of machinery is discussed both theoretically and practically in this article, the first on this specific subject. The elastic properties of rubber are described, formulae for designing rubber dampers are developed and examples are given of their use in the foundations of engines, etc.

Tuplin, W. A. Torsional Vibration in Machinery. Mechanical World, v. 98, no. 2537, Aug. 16, 1935. p. 143-146. (figures, table)

Description of general principles of torsional vibration. Explains the terminology and outlines the calculations necessary to safeguard against troublesome vibration. Mathematical work purposely avoided.

______________ Korfund Type "T" Seismo-Damper. American Machinist, v. 80, no. 4, Feb. 12, 1936. p. 177.

Description and application of the device for vibration isolation for medium and heavy machinery.

_______________ Isolate Vibration - If It Must Be Present. Machine Design, v. 8, no. 4, April 1936. p. 34-36, 79.

Result of laboratory and field tests made by a large industrial concern on the use of felt as a vibration isolator for machinery.

_______________ Preventing the Transmission of Machinery Vibration. Mechanical World, v. 100, no. 2588, Aug. 7, 1936. p. 127. (figures)

Rubber stretched evenly between two concentric steel tubes permits a certain movement of the tubes without surface friction. This is the Silentbloc principle, which, as described, has recently been applied to the damping of machinery vibrations.

_______________ Vibro-Insulator. American Machinist, v. 80, no. 23, Nov. 4, 1936. p. 939.

Three types of vibration-damping, rubber-to-metal mountings developed by the Goodrich Co. Description of mounting designed for bases of machines, electric and combustion motors, generators, vibrating screens and reciprocating mechanisms.

Gillen, G. M. Profiles for Propellers. Amer. Welding Soc.-Jl., v. 15, no. 6, June 1936. p. 9-10. (figures)

New propeller profiling machine designed by the Engineering and Research Corp. for cutting the profiles on metal blades for airplane propellers accurately to 0.002 in. Machine details given with reference to the elimination of vibration in the bed.

Smith, R. W. Rubber Mounting Solves Vibration Problem. Power, v. 80, no. 12, Dec. 1936. p. 681-682.
Also Rubber Age, v. 40, no. 4, Jan. 1937. p. 226. (figure)

Description of mounting used to solve the vibration problem present in a blower at the Ox Fibre Brush Co. of Seymour, Ind.

Süss, G. Betriebsstörungen an Maschinen durch Drehschwingungen. Praktische Maschinen-Konstructeur, v. 69, no. 13-14, July 1936. p. 176-179.

Operating failures on machinery resulting from torsional vibrations. Short graphical study.

Ziembinski, S. Une Hypothèse Nouvelle Concernant la Résistance des Pièces de Machines Soumises aux Vibrations. Tech. Autom. et Aérienne, v. 27, no. 174, 1936. p. 77-80. (figures)

When it is difficult to discover the cause of rupture in machinery, in most cases it may be found to be the amplification phenomenon of resonance. This hypothesis is introduced by the author with the expressed wish of experimentation in laboratories.

Hansel, L. H. The Vibration Isolation of Machinery. Electrical Engineering, v. 56, no. 6, June 1937. p. 735-738. (figures, references)
Also Steel, v. 99, no. 20, Nov. 16, 1936. p. 40-44.

Discusses the general principles of vibration isolation (vertical and horizontal) for machinery. Indicates the common errors made in installation (such as bridging) and the means for their correction.

## VIBRATION STUDIES IN ALLIED FIELDS - SHIPS.

Cole, A. P. The Natural Periods of Vibration of Ships. Inst. Engrs. and Shipbldrs. in Scotland-Trans., v. 72, 1928-1929. p. 43-86. (figures)

Purpose of paper is to introduce new formulae for the calculation of the periods of flexural and torsional vibrations and to indicate certain approximations which may be reasonably introduced whereby labor involved in evaluating these periods is appreciably reduced.

Curry, M. Why Not Propel Boats by Vibration? Scientific American, v. 141, no. 1, July 1929. p. 56-57. (figures)

A study of the vibratory principle of propulsion in nature, and the possibility of utilizing it for driving water craft.

Horn, F. Einfluss lokaler Gewichtsänderungen auf die Eigenschwingungszahl von Schiffen. Schiffbau, v. 30, no. 22, Nov. 20, 1929. p. 525-530. (figures, equations, references)

Investigation of the Schlick formula for vibration frequency. The author shows that frequency is definitely sensitive to weight distribution. Weight removed from position of greatest amplitude of vibration has the greatest effect in changing frequency and weight removed from the node has no effect. Numerical example considered and refers to cargo vessel of 110 m. in length and 9000 tons displacement.

Lewis, F. M. Ship Vibration. World Engineering Congress, Tokyo-Proc., Paper No. 457; v. 29, part I, (Shipbuilding and Marine Engineering), 1929. p. 193-212. (figures, bibliography)

Discussion of exciting causes and normal modes of vibration of hull structure; vibration producing forces of marine propellers. Reciprocating steam engine and Diesel engine are similar in their vibration producing characteristics; torque reaction and torsional vibration; turbines and auxiliary machinery. Computation of natural frequencies of hull; effect of hull structure upon vibration.

Moullin, E. B. Some Vibration Problems in Naval Architecture. Third Inter. Cong. for Appl. Mech.-Proc., v. 3, Aug. 1930. p. 28-30. (figures, references, discussion)

Problem of predicting the frequency of two or three node vibrations of a ship's hull is divided into three sections: (1) calculation of the frequency of a free-free bar whose line density and stiffness may vary in any manner along its length; (2) allowance to be made for sudden changes of stiffness, such as occur, for example, at an expansion point; (3) effect of surrounding water, which has a pronounced influence on the period of vibration and on the damping. The classic formulae of Schlick, comparing the ship with a uniform free-free bar, are used.

Roop, W. P. Natural Frequencies of Hull Vibration. Soc. Naval Architects and Marine Engrs.-Trans., v. 38, Nov. 13, 1930. p. 135-145. (appendix, figures, tables, discussion)
Also Marine Eng'g. and Shipping Age, v. 35, no. 12, Dec. 1930. p. 680.
Shipbldr. and Marine Engine Bldr., v. 38, no. 251, April 1931. p. 316-317.

Description of an experiment conducted in the U. S. Experiment Model Basin, Navy Yard, Washington, D. C., the object of which was to make accurate estimates of natural frequencies for use in design and, further, to obtain data on actual elastic characteristics. The results of tests conducted with this object in view are given.

Sulzer, R. Causes and Prevention of Vibration in Motor-Ships. Inst. Naval Architects-Trans., v. 72, 1930. p. 151-161. (figures)
Discussion p. 174-196.
Also Shipbldg. and Shipping Record, v. 35, no. 16, April 17, 1930. p. 497-499.
Engineering, v. 129, no. 3354, April 25, 1930. p. 551-554. Discussion - p. 529-530.
Engineer, v. 149, no. 3876, April 25, 1930. p. 468-469. Discussion - p. 453-455.
Shipbuilder, v. 37, no. 238, April 1930. p. 453-455.
Marine Engr. and Motorship Bldr., v. 53, no. 632, May 1930. p. 186-189.
British Motorship, v. 11, no. 122, May 1930. p. 76-78.
Sulzer Technical Review, no. 3, 1930. p. 6-16.

Attention first devoted to torsional vibration in crankshafts and intermediate shafting. Of greatest interest are conditions of 6, 8, 10, and possibly 12-cylinder engines which come into consideration mostly for passenger vessels. Vibration of hull may originate from free forces and moments from any part of machinery. Amplitudes increase with increase of imposed forces.

Taylor, J. L. Vibration of Ships. Inst. Naval Architects-Trans., v. 72, April 11, 1930. p. 162-196. (figures, discussion)
Also Shipbuilder, v. 37, no. 238, April 1930. p. 362-364.
Shipbldg. and Shipping Record, v. 35, no. 16, April 17, 1930. p. 500-501.

Primary object was the quantitative correlation of the results of calculated vibrations with actual measurements on shipboard, the latter having been obtained with the Cambridge low-periodicity vibrograph. Paper is divided into sections dealing respectively with the causes of vibrations encountered. Comparison of observed and calculated frequencies. Amount of damping and amplitude of vibration. Balancing of the machinery in the light of the amplitude calculation.

______________ Marine Oil-Engine Trials. Engineering, v. 132, no. 3437, Nov. 27, 1931. p. 680-682; no. 3438, Dec. 4. p. 711-715; no. 3439, Dec. 11. p. 724. (appendix, figures)
Discussion no. 3437, Nov. 27, 1931. p. 676-678.

Sixth report of the Marine Oil-Engine Trials Committee, giving the results of tests on T.S.M.S. "Polyphemus" and her engines. Covers trials ashore and at sea, and includes appendix on torsional oscillations occurring in crankshafts.

Bohuszewicz, O. and Späth, W. Dynamische Vorgänge an Schiffsschrauben. Werft-Raederei-Hafen, v. 12, no. 18, Sept. 15, 1931. p. 324-326. (figures)
Also Marine Engr. and Motorship Bldr., v. 54, no. 649, Oct. 1931. p. 397.

Method for determining the principal features of vibrations. Both horizontal and vertical oscillation can be distinguished and typical locations of these in twin-screw vessel are given. With single propeller, induced vibrations have a frequency equal to the products of blade number and propeller revolutions. On twin-screw ships, vibration is of varying intensity and arises from the difference in revolutions.

Lago, C. Algunos Experimentos y Aplicaciones de la Teoria Vibraciones. Ingenieria Naval, v. 3, no. 28, Dec. 1931. p. 562-567.

Some experiments and applications of the theory of vibrations in ships.

_______________ Vickers Oscillation Damper. Marine Engr. and Motorship Bldr., v. 55, no. 661, Oct. 1932. p. 347-348. (figures)

Vibration damper, particularly applicable to marine oil engines, placed on the market by Vickers-Armstrong. Geiger torsiographs of engine fitted with this damper.

Brown, J., Mellanby, A. L. and Shannon, J. F. Torsional Oscillations Occurring in Crankshafts. Engineering, v. 133, no. 3445, Jan. 22, 1932. p. 116-117. (figures, references)

Measurement of torsional oscillation; shop records; trials at sea. Appendix to Sixth Report of Marine-Oil-Engine Trials Committee, presented at the Institution of Mechanical Engineers.

Lago, C. Vibraciones Transversales de Vigas Rectas y Velocidades Criticas de Ejes que Giran Uniformente. Ingenieria Naval, v. 4, no. 29, Jan. 1932. p. 2-10.

Mathematical study of transverse vibrations of straight beams and critical velocities of shafts rotating uniformly as applied to ships.

Lago, C. Algunas Comprobaciones y Aplicaciones de la Teoria de Vibraciones Transversales de Vigas Rectas y de Velocidades Criticas de Ejes. Ingenieria Naval, v. 4, no. 30, Feb. 1932. p. 73-84.

Some comparisons and applications of the theory of transverse vibrations of straight beams and critical shaft speeds in ships.

Oehler, E. Fundamentschwingungen auf Schiffen. Schiffbau, v. 33, no. 6, March 15, 1932. p. 81-85.

Vibrations of ship-machinery which react on ship's hull. Calculation of vibrations in machinery foundations for angle-screw and twin-screw vessels.

________________ Oil Engine Generator Set with Anti-Vibration Attachment. Engineer, v. 156, no. 4048, Aug. 11, 1933. p. 144.

Set installed in Thornycroft-built motor-yacht Trenora. Anti-vibrator is incorporated beneath the baseplate of each set. Designed by W. Christie and Grey in collaboration with engine makers.

Inglis, C. E. A Suggested Method for Minimizing Vibrations in Ships. Inst. Naval Architects, v. 75, April 1933. p. 252-267. (figures)
Also Engineering, v. 135, no. 3510, April 21, 1933. p. 445-446. Discussion - no. 3512, May 5, 1933. p. 485.
Engineer, v. 157, no. 4080, March 23, 1934. p. 308-309.

Method suggested for minimizing transverse vibrations in girders is based on the old principle utilized to eliminate torsional oscillations in crankshafts. Mechanical principle explained. For a 1-node case of oscillation, if girder is of uniform mass and section, the damping device can take the form of two spring-supported masses, 1/100 the mass of the beam. Oscillations possessing intermediate nodes should employ two or more damping devices. Different forms of damper and applications explained. Use of damper in minimizing vibrations in individual beams of ships is suggested.

Schneider, E. Zykloiden-Treibflügel. Werft-Raederei-Hafen, v. 14, no. 12, June 15, 1933. p. 161-169.

Elaborate vector diagram analysis of reactions on impeller blades moving in helicoidal oscillating and cylindrical paths. Method is analogous to that employed in turbine blade design, and no reference is made to the modern theory of wing reactions.

Dimpker, A. Über schwingende Körper an der Oberfläche des Wassers. Werft-Raederei-Hafen, v. 15, no. 2, Jan. 15, 1934. p. 15-19.

Four cylinders of different cross-sectional forms, and of a few mm. less than the tank width in length, were constrained to oscillate in a vertical plane under spring control, the four sections being a circle, a rectangle, an equilateral triangle, and a flattened rectangle. Free and forced oscillations and wave formations observed. Approximate methods of calculation developed. The period, coefficient of damping (observed), and apparent mass (calculated) are shown graphically as functions of the maximum depth of immersion.

Keller, K. O. Torsional Oscillation in Marine Shafting. British Motorship, v. 14, no. 169, March 1934. p. 448-451. (figures)
Also Shipbldr. and Marine Engine Bldr., v. 41, no. 290, (Annual Int. No.), April 1934. p. 251.
Log, v. 23, no. 5, Aug. 1934. p. 7-10, 29.

Investigation with torsiograph revealed severe torsional oscillations at running speed. After mathematical investigation, a complete cure was effected. Dynamic characteristics of shaft systems. Comparative twist of steam and oil engine shafting. Results with twin-screw ships. Cause of crankshaft trouble.

Von den Steinen, C. Über die Zeitingrale ungedämpfter Schiffs-Schwingungen bei parabolischer Auftriebskurve. Werft-Raederei-Hafen, v. 15, no. 10, May 15, 1934. p. 115-122.

Time integrals of undamped ship vibrations with parabolic buoyancy curve. Theoretical mathematical study. Definition of additional stability; quasistatic vibrations; derivation of time formula; average values for speed.

Lewis, F. M. Propeller Vibration. Soc. Naval Architects and Marine Engrs.-Trans., v. 43, 1935. p. 252-285. (appendices, figures, table, equations, references, discussion)
Also Marine Eng'g. and Shipping Age, v. 41, no. 1, Jan. 1936. p. 34.
Shipbldr. and Marine Engine Bldr., v. 43, no. 316, (Annual Int. No.), April 1936. p. 266-269.

Classification of propeller vibration in a ship's hull. Methods proposed and described for avoiding propeller vibration. Reference is made to apparatus employed and procedure followed. Comparative effects of bearing forces and surface forces discussed. Results given of theoretical study made of propeller pulsating surface made by means of electrical model of the propeller vortex field. Hypotheses advanced to account for observed thrust deduction and vibratory forces. No final solution of problem was reached.

_______________ Notes on the S. S. "Normandie". Engineering, v. 141, no. 3673, June 5, 1936. p. 618.

Elimination of vibration in some passenger quarters, by arranging a pair of propellers on each side of the vessel so that they rotate in the same direction, upper blades of all propellers moving outward from the hull.

Bara, H. Cas d'Amortissement Anormal des Oscillations de Torsion. Assoc. Technique Maritime et Aeronautique-Bul. No. 40, 1936. p. 683-700. (discussion)

Damping of torsional oscillations. Case cited where actual theories seemed insufficient to explain certain peculiar conditions of vibration damping of motorship shafts. This abnormal damping, in the author's opinion, is related to the influence of carbine and particularly to maintenance of synchronous vibrations of carbines.

Coquerot, F. and Romano, P. Vibration Problem on the Normandie. Soc. Naval Architects and Marine Engrs., Meeting Paper (N.Y.), Sept. 16, 1936.
Also Marine Eng'g. and Shipping Rev., v. 41, no. 10, Oct. 1936. p. 559-562. (figures)
Engineer, v. 162, no. 4214, Oct. 16, 1936. p. 416-418.
Marine News, v. 23, no. 5, Oct. 1936. p. 26-29.
Engineering, v. 143, no. 3706, Jan. 22, 1937. p. 103-106.

During several trips, research into the vibration problems on the Normandie were conducted and experiments with the proposed solutions were made. Data on vibration was collected. Vibration was traced to the propellers. Experimental tests were made on propeller vibration with models at the Hamburg tank. Several unsuccessful attempts at remedying propeller vibration is discussed. A new type of propeller was used.

Dorey, S. F. Marine Machinery Defects - Their Causes and Prevention. Inst. Marine Engrs.-Trans., v. 47, no. 12, Jan. 1936. p. 305-383. (discussion)

Also Mechanical World, v. 99, no. 2557, Jan. 3, 1936. p. 7-9,23; no. 2558, Jan. 10. p. 39-40; no. 2559, Jan. 17. p. 63-64; no. 2560, Jan. 24. p. 85-87.
Marine Engineer, v. 59, no. 700, Jan. 1936. p. 10-12; no. 701, Feb. p. 47-49; no. 702, March. p. 77-79.
British Motor Ship, v. 16, no. 191, Jan. 1936. p. 394-395.
Heat Treating and Forging, v. 22, no. 2, Feb. 1936. p. 66-70; no. 3, March. p. 123-127.
Shipbldr. and Marine Engine Bldr., v. 43, no. 316 (Annual Int. No.), April 1936. p. 290-294.
Log, v. 27, no. 6, Sept. 1936. p. 8-12.
Engineering, v. 140, no. 3649, Dec. 20, 1935. p. 667-668.
Shipbldg. and Shipping Record, v. 46, no. 24, Dec. 12, 1935. p. 656-660.

Defects frequently encountered in forgings of marine reciprocating engines in service, e. g., screw shafts, crankshafts, piston and connecting rods, crossheads and bolts. Cases of failures encountered in piston rods, connecting rods and crossheads. Causes and means of preventing breakage in bolts.

Hiersac, J. Comment Lutter contre les Vibrations à Bord des Navires? La Science et la Vie, v. 49, no. 227, May 1936. p. 377-386. (figures, table, references)

Author discusses the case of the S. S. Normandie, which, after her first voyage, was put in repair to eliminate the vibrations in it. The author considers the causes of the phenomena, other than resonance, among them so-called "cavitation" of the propeller. He refers to the description of a device for the measurement of vibrations "monographsphotocathodic" by Labarth (No. 195, La Science et la Vie) and promises to describe another apparatus for measurement of vibrations - piezoelectric vibrograph accelerometer by Beaudouin.

## VIBRATION STUDIES IN ALLIED FIELDS - STEAM TURBINES

Campbell, W. and Heckman, W. C. Tangential Vibration of Steam-Turbine Buckets. A.S.M.E.-Trans., v. 47, Paper No. 1975, 1925. p. 643-671. (figures, equations, discussion)

Description of how research was extended to include tangential vibration. Substantially the same testing apparatus was used and the same methods of protection adopted. Resonant conditions are avoided by carefully prescribed margins. In unsymmetrical reaction buckets, compound vibration lying most nearly in plane of wheel is, by definition, treated as tangential vibration. Methods described suffice for protection against any combined or intermediate type.

Freudenreich, J. Vibration of Steam-Turbine Discs. Engineering, v. 119, no. 3079, Jan 2, 1925. p. 2-4; no. 3080, Jan. 9. p. 31-34. (figures, references)

The exhaustive tests on the vibrations of discs carried out at the works of Brown, Boveri and Co. have been described, and the main formulae quoted from the theory due to Prof. Stodola. It appears that the whole problem of disc vibration may now be solved both theoretically and practically, and that discs may now be designed which will be quite free from vibration under all working conditions.

Hort, W. Beanspruchung von Stäben durch erzwungene gedämpfte Schwingungen. Zeit. Tech. Phys., v. 6, no. 6, 1925. p. 216-221. (figure, equations)

Treatise considers the possibility of resonance with superior harmonics.

Blaess, V. Über den Massenausgleich raschumlaufender Körper. Z.A.M.M., v. 6, no. 6, Dec. 1926. p. 429-448. (figures, equations, references)

Differential equations solved for a variety of conditions (out of balance masses, elastic supports or foundations) and elucidated graphically. Test methods discussed, and the importance of systematic investigation of high speed machinery emphasized.

Hort, W. Die Schwingungen der Räder und Schaufeln in Dampfturbinen. Z.V.D.I., v. 70, no. 42, Oct. 16, 1926. p. 137

1381; no. 43, Oct. 23, p. 1419-1424. (figures, equations, references)

Causes and effects of oscillations. Measurements and calculation of oscillations in turbine disks. Calculation of stresses in turbine blades caused by oscillations. Means of preventing oscillations.

Suyehiro, K. The Gyroscopic Vibration of Marine Steam-Turbine Discs. Engineering, v. 122, no. 3173, Nov. 5, 1926. p. 581-582. (figures)

Vibrations in steam turbines. Deals with the effect of yawing or pitching of turbine ship on turbine discs, which are thereby set into processional motion.

Housley, J. E. A Remedy for a Case of Turbine Vibration. Power, v. 66, no. 8, Aug. 23, 1927. p. 286-287. (figures)

Experience with a vertical 2250 kw. turbine operating at 900 r.p.m.

Jaquet, E. Berechnung der Eigenfrequenzen von Dämpfturbinenschaufeln. Schweizerische Bauzeitung, v. 90, no. 1, July 2, 1927. p. 1-3. (figures)

Grapho-analytical method especially adapted for the case of cylindrical blades with shrouding or other single mass at free ends. Curves for quick determination of fundamental and superimposed (overtone) vibrations given.

Kimball, A. L. and Lovell, D. E. Internal Friction in Solids. Mechanical Engineering, v. 49, no. 5, May 1927. p. 440-444. (figures, tables, equations, references, discussion, bibliography)

The present investigation is the outcome of a study by one of the authors of the effect of the internal friction within the metal of a steam-turbine in dissipating vibration and also of the effect of internal friction within a rotor and a shaft in producing whipping. A test devised to determine the amount of friction within the metal of a steel shaft. The apparatus with which the tests were conducted is described, and the results are tabulated. Equations relating to the variables involved are derived in the analysis of the problem.

Schwerin, E. Über die Eigenfrequenzen der Schaufelgruppen von Dampfturbinen. Zeit. Tech. Phys., v. 8, no. 8, 1927. p. 312-319. (figures, tables, equations)

Vibration periods determined of groups of steam turbine blades. Mathematical analysis, with numerical examples, showing difference in vibration period of individual blades and groups of blades.

Bauer, G. Recent Developments of the Exhaust-Steam Turbine. Shipbuilder (Newcastle-on-Tyne), v. 35, no. 213, May 1928. p. 336-341. (figures)

Experience in manufacture of gearing, of elastic couplings, and of vibration phenomena in rotary systems, has made possible the combination of piston engine and exhaust turbine on one propeller shaft. Attention is drawn to features of such combination known as the Bauer-Wach system.

Eck, B. Versteifender Einfluss der Turbinenscheiben auf die Durchbiegung des Läufers. Z.V.D.I., v. 72, no. 2, Jan. 14, 1928. p. 51-56. (figures)

Theory for determining the stiffening effect of turbine discs, both in the case of integral discs and discs which are keyed on or shrunk on. Theory useful in determining critical velocity of complete machines; it indicates how much speed increase possible without sacrificing safety of plant.

Hort, W. Studien über Schwingungen von Kreisplatten und Ringen. Schweizerische Bauzeitung, v. 92, no. 23, Dec. 8, 1928. p. 285-288; no. 25, Dec. 22. p. 315-317. (figures, references)

Review of experimental research. Theory of period frequency of transverse vibrations in circular plates having a hole in the center. Experimental verification of theory making use of Chladni's figures. Bearing of theory on turbine design discussed.

Mensch, G. Rechnerisch Ermittelte und Gemessene Schwingungenszahlen an einem Turbinenfundament. Bauingenieur, v. 9, no. 9, March 2, 1928. p. 152-163. (figures)

Plan and section of 12,500 kw. turbo-generator installation at Wilmersdorf power plant, of Elektricitaetswerk, Sudwest A.G. Comparison of vertical and horizontal vibrations of the foundation, as determined mathematically and as actually measured by means of Schenk instrument, shows that computed values are in excess of measured values.

Rathbone, T. C. Vibration of Turbine-Generator Foundations. Power, v. 67, no. 14, April 3, 1928. p. 588-592. (figures)

It is pointed out that the customary efforts to avoid resonance by design are quite insufficient. Most structures are too complex to predetermine many modes of vibration, and many harmful or beneficial features affecting smooth running are too often overlooked. Discussion of mass and electricity effects on natural frequencies. A chart is presented for finding critical speed coefficients.

Rathbone, T. C. Curing Resonant Vibration in Turbine Units. Power, v. 67, no. 15, April 10, 1928. p. 629-632. (figure)

Methods of correcting resonance conditions when encountered in operating units. Vibration reduced by change in foundation loading. Floor vibrations discussed. Internal and external friction retards vibration.

Anoschenko, B. Increasing the Life of Steam Turbine Blades. Electric Jl., v. 26, no. 2, Feb. 1929. p. 86-87. (figures)

Description of machine for determining performance of turbine blades under vibration and comparison of effect of three different methods of lashing on blade life.

Doucet, M. Determination du Nombre de Tours Critiques. Assoc. Technique Maritime et Aeronautique-Bul. No. 33, 1929. p. 429-443. (figures)
Also Shipbuilder, v. 37, no. 238, April 1930. p. 465-466. (figures)

Simple methods for calculating critical speeds in line shafting and in turbine shafts. Hypothesis is given that shaft may be divided into sections carrying at each extremity concentrated mass; system of such masses is dynamically equivalent to given system.

Kayser, H. Über Fundamentschwingungen. Z.V.D.I., v. 73, no. 37, Sept. 14, 1929. p. 1305-1310. (figures, references)

Principles of new methods for computing resonance by means of energy equations. Report on observations and means of measuring vibrations of turbine foundations. Comparison of calculated and observed results. Effect of nature of foundation site. Dead-load compensation for dynamic stresses.

Rathbone, T. C. Turbine Vibration and Balancing. A.S.M.E.-Trans., v. 51, APM 51-23, 1929. p. 267-284. (figures, references, discussion)

Limitations discussed of latest analytical methods employed in correcting balance of turbine-generator rotors at speed and in operation. Strobo-vibroscope developed to study motion in a complex system is described, with results of experiments made on a large rotor by means of this instrument. Method of balancing is then described, which takes into account the interaction of vibratory impulses communicated from one bearing to another, thus overcoming the chief difficulty with present methods. Proposed method also provides means of evaluating the sensitivity of any installation for comparative study of strucutres. Also included is a discussion of various factors, other than simple unbalance, which affect the vibration of large units, with references to some unusual cases encountered.

Kayser, H. and Troche, A. Theoretische Betrachtungen und ausgeführte Versuche über Fundamentschwingungen. Beton und Eisen, v. 24, no. 1, Jan. 5, 1930. p. 15-18. (figures)

Vibrations in foundations of turbines and other rotary machines are discussed from the mathematical point of view, and formulae are developed for calculating revolutions per minute which will produce marked resonance.

Troche, A. Resonanzberechnung von Trägern und Rahmen nach der Arbeitsgleichung. Beton und Eisen, v. 29, no. 6, March 20, 1930. p. 119-125; no. 7, April 5. p. 133-139. (figures)

Theoretical, mathematical analysis including results of experiments on models, leading to derivation of formulae for computation of vertical, horizontal and torsional resonance, with special reference to vibration in turbine foundations, considering foundation structures as a whole.

Collingham, R. H. Axial Vibration of Rotating Steam Turbine

Disc Wheels. Engineer, v. 151, no. 3925, April 3, 1931. p. 370-372; no. 3926, April 10. p. 402-404. (figures)

April 3 - Type of vibration responsible for practically all serious wheel troubles consists of train of backward-traveling waves. Question of designer's ability to calculate turbine disc wheel to be free from critical nodal vibration; it is shown how difficult it is to calculate critical speed of nodal vibration of wheel disc by theoretical considerations. April 10 - Electrical connections of various exploring coils, electrical circuits of amplifiers used, of oscillograph and of exciting magnet used in tests shown diagrammatically. Outline of procedure followed in developing design of new turbine disc wheels.

Pochobradsky, B., Jolley, L. and Thompson, J. S. Experimental Investigation of Vibrations in Turbine Wheels and Blades. Engineering, v. 132, no. 3433, Oct. 30, 1931. p. 541-545. (figures, tables, references)

General consideration of causes and effects of vibration in steam turbines, also consideration of vibration of stationary and of rotating wheels. Work described was done in special laboratory equipped by General Electric Co. A static tester and a blade tester were used. Methods of measurement and details of tests stated. Experiments conducted to verify standard formula for natural frequency of a bar clamped at one end and vibrating in a transverse direction.

Bächtold, J. Schwingungen von Maschinenfundamenten. Schweizerische Bauzeitung, v. 100, no. 13, Sept. 24, 1932. p. 167-169. (figures)

Theoretical, mathematical discussion of vibrations in foundation frames of steam turbines and similar heavy machinery.

Gönczy, G. Mechanische Resonanzschwingungen an einer Turbogruppe. Electrotechnische Zeit., v. 54, no. 12, March 23, 1933. p. 279-281. (figures, references)

Description of an investigation into the vibration occurring in a 36,000 k. VA turbo-alternator. A vibrograph used, and the vibration traced to the bearing between the turbine and alternator. The base plate of the bearing was replaced by a thicker one and the troubles cured.

Reissner, H. Formänderung, Spannung und kleine Schwingungen von Stäben mit anfanglicher Krümmung und Verwindung die um eine Querachse rotieren. Ingenieur Arch., v. 4, no. 6, Dec. 1933. p. 557-569. (figures, equations)

The problem of propeller blades and turbines considered from the kinematic and dynamic standpoint. The various forces analyzed and special attention given to the centrifugal force due to rotation. It is found that the torsional oscillations are not practically influenced by the camber of the baricentric line, while the propeller thrust has an influence of the first order on the torsional oscillations. Differential and integral equations on oscillation follow.

Sezawa, K. Vibrations of Turbine Blades with Shrouding. Phil Mag., S. 7, v. 16, no. 103, July 1933. p. 164-174. (figures, tables, equations, references)

Theoretical, mathematical analysis with special reference to cases in which effects of rotation and of flexural rigidity are neglected.

______________ Steam Turbine Vibrations. Shipbldr. and Marine Engine Bldr., v. 41, no. 288, March 1934. p. 117-118.

Consideration of fundamental of steam turbine vibrations. Importance of eliminating as far as possible all out-of-balance forces.

______________ Vibration of Steam Turbines. Engineer, v. 158, no. 4103, Aug. 31, 1934. p. 213-214.

Discussion of wheel vibration in steam turbines as one of the major nuisances which may afflict the turbine user.

Baker, J. G. Investigation of Axial Oscillation of Turbine Generator Spindles. Fourth Inter. Cong. Appl. Mech. - Proc., July 1934.

A new vibration problem in 3-turbine generators encountered The rotors under certain conditions would oscillate in the direction of their axes. Phenomenon due to the instability of free vibration. Causes of the instability. Cures for the trouble. Records of the motions and pressures which were made with special apparatus. Results of a model test for determining thermal stress introduced by the change made in the piping of the machine are reported.

Karas, K. Die Schwingungen von Dämpfturbinen-schaufeln. Ingenieur Arch., v. 5, no. 5, Oct. 1934. p. 325-352. (figures, tables, equations, references)

The general differential equation is formed for blade vibration in the plane of rotation, taking into account centrifugal action. An example is worked out numerically, the result being in fair agreement with experimental values.

Melan, H. Festigkeitsberechnung bei Turbinenschaufeln. Z.V.D.I., v. 78, no. 13, March 31, 1934. p. 396-397.

Consideration in some detail of the creation of vibrations in blades. In the last rows of blades, the problem is to calculate the natural periods of vibration in the blades and to lay out the blades so that their natural periods of vibration should be from two to three times higher than the operating periods of vibration. The results of approximate processes for this kind of calculation, only recently published, have been confirmed by practical experience.

Ono, A. and Ishibashi, T. Vibrations of Blades Caused by Lateral Vibrations of Turbine Disc. Soc. Mech. Engrs. (Japan)-Jl., v. 37, no. 201, Jan. 1934. p. 1-4. (In Japanese with brief English abstracts. p. S-1)

Mathematical experimental studies of motion of mass placed on elastic bar. Arrangement is such that mass has different frequencies of natural vibrations in two directions. If frequency in circumferential direction is equal to that of disc, or to its multiple, resonance occurs, and mass vibrates in circumferential direction. Phenomenon is explained theoretically.

Peter, W. Contribution to the Calculation of Blade Vibration in Steam Turbines. Brown Boveri Rev., v. 21, no. 5, May 1934. p. 79-82; no. 7, July. p. 123-127. (figures, equations)

Theoretical mathematical design analysis.

Soderberg, C. R. Recent Developments in Steam Turbines. Mechanical Engineering, v. 57, no. 3, March 1935. p. 155-173. (figures, tables)

Included is a discussion of blading in relationship to maintenance of steam turbines. Electromagnetic vibration tester, in which structures can be tested to destruction under frequencies as high as 20,000 cycles per sec. Methods of stiffening blades, (in the last rows on large condensing turbines) which are subject to many forms of vibration. Discussion of blade failures in the low-pressure end; exact mechanism of these blade failures not known. Discussion of damping; outside of this consideration, there remains the requirement of making the blade construction as immune as possible to vibratory stresses. Electromagnetic tester useful for this. Difficulties in devising a conclusive method of interpretation of test results obtained by this method. Valuable information on the subject of damping can be obtained by exploring the blade vibrations during rotation.

Paget, A. L. Vibration in Steam Turbine Buckets and Damping by Impact. Engineering, v. 143, no. 3174, March 19, 1937. p. 305-307. (figures, references)
Discussion no. 3717, April 9. p. 401; no. 3718, April 16. p. 440-441; no. 3720, April 30. p. 488; no. 3722, May 14. p. 549; no. 3723, May 21. p. 577; no. 3724, May 28. p. 616.

Vibration in steam-turbine buckets and turbine wheels; damping by impact described. Use, in general, of a camera for recording vibrations.

## VIBRATION STUDIES IN ALLIED FIELDS -- MISCELLANEOUS

Kühnel, - Die Gefahren der Schwingungsbeanspruchung für den Werkstoff. Z.V.D.I., v. 71, no. 17, April 23, 1927. p. 557-561. (figures)

Numerous examples given from the German Experimental Bureau showing the danger of vibration stress to material when additional effects of any nature occur. From the appearance of the fracture, it is possible, to a certain extent to determine the origin of the fracture.

_______________ Schwingungen von Schornsteinen. Beton u. Eisen, v. 27, no. 21, Nov. 5, 1928. p. 400-401.

Formula developed by N. Monomobe, Tokyo, for computing the frequency of free vibration of hollow truncated cones, is recommended for use in investigating vibration of tall chimneys. Frequencies of several chimneys and lighthouses as calculated from this formula and as measured, are compared, and official specification is advocated of lower limit for frequency of chimney stacks and similar structures liable to be set in vibration by wind.

Inglis, C. E. Oscillations in a Bridge Caused by the Passage of a Locomotive. Roy. Soc.-Proc., v. 118, no. A779, March 1, 1928. p. 60-96.

This problem is analogous in many ways to the vibration of an aeroplane structure. Analysis developed is of interest to an aeroplane designer, particularly in the expressions for deflections, natural periods and forced oscillation.

Lehr, E. Schwingungen von Schornsteinen. Beton u. Eisen, v. 27, no. 16, Aug. 20, 1928. p. 301-316. (figures)

On the basis of analogy with astatic pendulum and leaf springs, the author develops a graphical method of computing the period of vibration of chimneys for various intensities of lateral impulses. Effect of vibrations on stability of structure.

Saller, - Dynamik und Schwingungen des Eisenbahnoberbaues. Z.V.D.I., v. 72, no. 38, Sept. 22, 1928. p. 1323-1329. (figures)

Paper read at Darmstadt conference on vibrations at the Society of German Engineers, on the effect of vibrations on railroad track and its bearing on selection of materials and type of construction for ties and rail joints. Methods of measuring vibration stresses. Description of Okhuisen and Geiger instruments. Comparison of simultaneous vibration records, obtained by Geiger and Okhuisen instruments, for trains moving with velocities of from 22 to 90 km. per hour.

Timoshenko, S. Vibration of Bridges. A.S.M.E.-Trans., v. 50, R.R. 50-9, 1928. p. 53-61. (appendix, figures, equations, references, discussion)

In the appendix, the problem of vibrations of bridges is discussed in general by considering the bridge as a beam of uniform cross-section, simply supported at the ends. Mathematical treatment.

Langsdorf, A. S. Oscillations of Compound Springs. Washington Univ. Studies, Science and Technology, no. 3, Oct. 1929. 17 p. (figures)

In order that springs of compound type may be designed to minimize oscillations under given operating conditions, it is necessary to analyze their performance by mathematical methods so as to derive formulae in terms of spring constants. Accordingly, an analysis has been worked out to cover any general case.

Rockefeller,Jr., J. W. Time of Oscillation in Helical Springs. Machinery (N.Y.), v. 35, no. 10, June 1929. p. 748-751. (figures)

Charts for determining the period of vibration and damping factor in the design of helical springs are given and discussed.

Slocum, S. E. Tests of Traffic-Vibration Dampers for Buildings. Engineering News Record, v. 102, no. 10, March 7, 1929. p. 377-379. (figures)
Also Amer. Soc. Civil Engrs.-Proc., v. 55, no. 8, Oct. 1929. p. 2109-2129. Discussion v. 56, no. 1, Jan. 1930. p. 153-158; no. 5, May. p. 1177-1195.

Results of original research in connection with the problem of preventing vibration in structures, as applied to terminal improvements of the Pennsylvania R.R. at Philadelphia, to provide against vibration due to operation of trains. Details are given of load and vibration test apparatus; vibrograph records; corkboard as damper; hair felt, rubber and asphalt; composite pads; load deflection curve for single lead-and-asbestos pad.

Hildebrand, L. E. Quiet Induction Motors. A.I.E.E.-Jl., v. 49, no. 1, Jan. 1930. p. 7-11. (appendix, figures)

Magnetic noise in induction motors is caused by vibration of magnetic parts produced by varying forces associated with changing flux density in adjacent air parts of the magnetic circuits; torsional windings or applied voltages; causes of vibration of rotor and stator; magnetic noise can be predicted from qualitative analysis of air-gap field supplemented by analysis of stiffness of parts.

Panetti, M. Notizie Generali sulle Oscillazioni dei Veicoli. Third Inter. Cong. Appl. Mech.-Proc., v. 3, Aug. 1930. p. 16-27. (figures, equations)

Review of the existing literature on vibrations in side-rod electric locomotives and automobiles. Mathematical relationships of various kinds of vibration and examples given.

Parodi, M. H. Etude sur les Oscillations des Systemes de Transmission par Bielles des Locomotives Electriques. Third Inter. Cong. Appl. Mech.-Proc., v. 3, Aug. 1930. p. 234-250. (figures, equations)

Transmission systems of connecting rods of locomotives divided into two categories: (1) hyperstatic; (2) isostatic. Vibrations, in the first case, are expressed by differential linear equations with periodic coefficients. The critical speeds exist in zones more or less large, in which all speeds are critical. Vibrations, in the second case, are expressed by differential linear equations with constant coefficients. Introduction of analytical and graphical methods of study of vibrations as defined by differential linear equations for both systems.

____________. Physical and Physiological Aspects of Vibration. Engineer, v. 152, no. 3958, Nov. 20, 1931. p. 547-548.

Study of the subject suggests that the effect of vibration on human senses is in general to be distrusted as an indication of their effect on mechanical contrivances and structures. The miraculous possibility is suggested that the effect of vibration on human frames may be serviceable when applied to machines or structures.

Adrian, W. Zeitfragen Mechanischer Schwingungen. Z.A.M.M., v. 11, no. 5, Oct. 1931. p. 382-387.

Report of the meeting of the committee on mechanical vibration of the Association of German Engineers held in Munich, May 1931. The work outlined and discussed includes that of Klotter on vibrations in systems in which the elasticity is variable and that of Poschl on the vibration of beams. The vibrations of fibres, rods, plates and membranes are discussed. Reiher's work on the vibrations produced by traffic and on vibrations in structures is discussed in relation to the form frequency and permissible limits of oscillation which may be detrimental to the building or to the persons therein. Much research being carried out on fatigue. Some details given of Isemer's work on screws and of Hoffmann on the occurrence of polydimensional mechanical vibrations. More than twenty other papers dealing with research on vibrations in structures, vehicles and machines, with testing apparatus and instruments, are noted.

Goodier, J. N. Vibrations of Railway Bridges. A.S.M.E.-Trans., v. 53, APM 53-2, 1931. p. 13-25. (appendix, figures, equations, references, discussion)

Discussion of the nature of the approximately resonant vibrations of bridges due to the pulsating forces generated by unbalanced drives, the influence of the motion of the train, and probable action of the spring. A group of proposed approximate formulae for predicting the natural frequencies of bridges, whether unloaded or supporting trains. Description given of the methods of measuring natural frequencies. A list of the sources of damping. A theoretical demonstration of the effects of a small amount of distributed damping in restraining the forced vibration, and an appendix in which the frequency formulae are derived.

Reiher, H. and Meister, F. J. Die Empfindlichkeit des Menschen gegen Erschütterungen. Forschung auf dem Gebiete des Ingenieurwesens, v. 2, no. 11, Nov. 1931. p. 381-386. (figures, table, references)

Sensitivity of the human body to vibrations. Arrangement of apparatus and manner of tests. Evaluation of test results. Comparison with earlier results.

Schmidt, H. Theorie der Biegungsschwingungen frei aufliegender Rechteckplatten unter dem Einfluss beweglicher, zeitlich periodische veränderlicher Belastungen. Ingenieur Arch., v. 2, no. 4, Nov. 1931. p. 449-471. (figures, equations, references)

Theory of the free bending vibrations of a rectangular plate with periodically variable load. This method may be practically applied in calculations for reinforced concrete bridges.

_______________ Multiple Periods in Vibration of San Francisco Buildings. Engineering News Record, v. 108, no. 25, June 23, 1932. p. 886.

Observations on 15 high structures show short-period movements in addition to fundamentals. Marked vertical component observed in several of them.

_______________ Suspension Bridges. Engineering, v. 134, no. 3494, Dec. 30, 1932. p. 769-770. (references)

Collapse of suspension bridge at Angers in 1850 claimed to be caused by attempted passage over it of a regiment of soldiers. Bridge swayed in response to cadence of soldiers' footfalls. Once the oscillation started, the men emphasized their tread in time with it. Result was a collapse. Brief description is given of precautions used to prevent collapse of George Washington Bridge as a possible result of excessive vibrations.

Desprets, R. Actions Dynamiques des Charges Roulantes, sur les Ponts des Chemins de Fer. Annales des Ponts et Chaussées (Partie Technique), v. 2, no. 6, Nov.-Dec. 1932. p. 325-410. (figures)

Theoretical, mathematical analysis of dynamic effects of rolling loads on railroad bridges. Investigation of several particular cases of loading. Effect of centrifugal force on deformation. Review of earlier studies by Renaudot, Bresse, Souleyre and Deslandres, and also of experimental studies of America, Great Britain, etc. Computation of periods of vibration and frequencies.

Katel, I. Les Graves Inconvenients de la Résonance due aux

Machines Installées dans les Bâtiments. Technique de la Suisse Romande-Bul., v. 58, no. 24, Nov. 26, 1932. p. 312-315.

Analysis of data on extreme vibration resonance in buildings due to machines installed in them.

Koch, H. W. Messung von Schwingungen am Eisenbahnoberbau. Organ für die Fortschritte des Eisenbahnwesens, v. 87, no. 21, Nov. 1, 1932. p. 389-399. (bibliography)

Report on experimental study of vibrations, particularly in railroad tracks, made at Hanover Institute of Technology. Critical discussion of methods used. Dynamic theory of track vibrations. Comparative discussion of results obtained by the author with those available in literature and with theoretically derived values.

Santo Rini, P. Sur un Procède à Haute Fréquence pour l'Etude des Vibrations tant à la Surface, qu'à l'Intérieur d'un Solide, en Particular des Membrures d'un Pont. Inst. de France, Acad. des Sciences, Comptes Rendus, v. 194, no. 11, March 14, 1932. p. 955-957.

Description of a high-frequency process for the study of vibrations on the surface as well as on the interior of a structure, particularly of the framework of bridges. Use of condensator-explorer and absorbomicrometer.

Biot, M. Theory of Elastic Systems Vibrating Under Transient Impulses with an Application to Earthquake-Proof Buildings. Natl. Acad. Sci.-Proc., v. 19, no. 2, Feb. 1933. p. 262-268. (figures, equations, references) Also Guggenheim Laboratory (Pasadena) Rep. No. 28.

Theoretical, mathematical study of elastic systems vibrating under transient impulses with an application to earthquake-proof buildings. It was shown that fundamental oscillation is by far the most dangerous.

Bradbury, C. H. Vibration in Roads and Buildings. Surveyor, v. 84, no. 2183, Nov. 24, 1933. p. 495-496.

Vibration of elastic bodies. Principles of vibration transmission; transmission of ground waves; properties of vibration insulators; causes and prevention of vibration; vibration of buildings.

Förster, R. Über Schüttel- und Zitterschwingungen. Arch. für Elektrotechnik, v. 27, no. 5, May 2, 1933. p. 307-321. (figures)

Shaking and trembling type of vibrations causing hunting vibrations in such oscillatory systems as driving rods of electric locomotives, in spindles of small electric clocks driven by single phase synchronous motors, in a.c. motors, etc., are analyzed.

Genest, W. Schall- und Schwingungsdämmung im Hochbau. Z.V.D.I., v. 77, no. 16, April 22, 1933. p. 427-428. (references)

Compilation of recently published German data on elimination of sound, noise and vibrations in buildings.

Kohler, R. and Ramspeck, A. Übertragung von Maschinenschwingungen auf Boden und Gebäude. Z.A.M.M., v. 13, no. 6, Dec. 1933. p. 435.

Measurements to determine the nature of transmission of mechanical oscillation in the soil were carried out with a variable frequency vibrator and seismograph. The natural frequencies of the soil were found to be very pronounced, and considered to be of great importance when dealing with the problem of transmission of vibrations through the soil. Similar experiments now in progress in connection with the transmission of engine vibration to a building.

Ozawa, K. Forced Vibration of Bridge under Action of Running Vehicle with Spring. Soc. Civil Engrs. (Japan)-Jl., v. 19, no. 6, June 1933. p. 429-444. (In Japanese)

Theoretical, mathematical discussion of the forced vibration of a bridge under action of a running vehicle with spring.

Renton, C. and Doak, W. J. Oscillation of Railway Carriages on Long Bridges in Queensland. Railway Engr., v. 54, no. 644, Oct. 1933. p. 298-301. (appendix, figure)

Measures taken to detect, measure and obviate excessive vertical oscillation in certain vehicles on particular bridges. Typical records of car oscillation tests on bridges. Apparatus used for tests.

Scharrer, G. and Brötz, O. Gebäudeschwingungen. Forschungsheft 359, March-April 1933. 24 p. (figures, tables, references)

Two studies on effects of vibration in buildings caused by traffic or machinery, and ways of preventing them. Method developed for predetermining the natural period of vibration of building sufficiently exact for practical purposes. Results of measurements on floors, walls, and brick piers. Methods for preventing or reducing harmful vibrations.

Spilker, A. Bauwerksschwingungen. Bauingenieur, v. 14, no. 47-48, Nov. 24, 1933. p. 575-577; no. 49-50, Dec. 8. p. 597-598. (bibliography)

Mathematical theory of damped vibrations. Review of causes and effect of vibrations occurring in buildings. Methods of reducing or eliminating vibrations in buildings.

Biot, M. Theory of Vibration of Buildings During Earthquake. Z.A.M.M., v. 14, no. 4, Aug. 1934. p. 213-223. (appendices, figures, references) (In English) Also Guggenheim Laboratory (Pasadena) Rep. No. 48.

Relation between frequency spectrum of transient impulses and its effect on undamped elastic system as applied to earthquake-proof building with "elastic first floor".

Den Hartog, J. P. The Vibration Problem in Engineering. Fourth Inter. Cong. Appl. Mech.-Proc., July 1934. p. 36-53. (figures, references)

Review of some of the applications of the theory of vibration to practical engineering problems which have occurred in the past ten years. Most notable problems in the past few years lie in the fields of self-excited vibrations such as occur in flutterings of airplane wings. These are divided into three groups: (1) instabilities caused by friction, either dry or oil film; (2) phenomena on stretched wires, e.g., transmission lines, embracing those caused by vortex formation, those caused by inherent non-symmetry in the flow pattern and those explained by the finite time of formation of turbulence. Some unexplained phenomena discussed; (3) vibrations caused by leakage flow in engine valves and steam turbines. Miscellaneous results discussed. The problem of transients while accelerating through critical speed. New balancing machine constructed by Thearle, incorporating suggestions of Leblanc. New graphical solution of balance problem and new application of dynamic vibration absorber.

Mogami, T. Vibration of Suspension Bridge. Soc. Civil Engrs. (Japan)-Jl., v. 20, no. 6, June 1934. p. 549-568. (In Japanese)

Theoretical, mathematical discussion of vibration of suspension bridges.

Pagon, W. W. Vibration Problem in Tall Stacks Solved by Aerodynamics. Engineering News Record, v. 113, no. 2, July 2, 1934. p. 41-43. (figures)
Discussion no. 7, Aug. 16. p. 217; no. 12, Sept. 6. p. 309; no. 18, Nov. 1. p. 565.

Analysis of data on deflections, wind velocity and direction and eddy frequency, dictated the use of new trusses in supporting structure and ring stiffeners in stack with crossed diagonals; observed vibrations; recording equipment; eddies around stacks; vibration correction and results of alterations.

Pohl, K. Zur Berechnung der Eigenschwingungenszahl von Balkenträgern. Stahlbau (Suppl. to Bautechnik), v. 7, no. 23, Nov. 9, 1934. p. 177-179. (figures, tables, equations, references)

Mathematical theory of the determination of the period of vibration of solid web and framed girders; numerical examples.

Steuding, H. Die Schwingungen von Trägern bei bewegten Lasten. Ingenieur Arch., v. 5, no. 4, Aug. 1934. p. 275-305; v. 6, no. 4, Aug. 1935. p. 265-270. (figures, tables, equations)

The use is considered of a heavy beam simply supported, and uniformly loaded from one end by a movable section with uniform motion (the case of a train entering a bridge) and then the same beam loaded on all its length. This is followed by consideration of the use of a beam supported at one or both ends with movable, concentrated load.

Stüssi, F. Zur Berechnung der Grundschwingungszahl vollwandiger Träger. Schweizerische Bauzeitung, v. 104, no. 17, Oct. 27, 1934. p. 189-191. (figures; equations, references)

Theoretical, mathematical discussion leading to derivation of formulae of period of vibration of solid web beams.

______________ Isolation of Vibration and Noise. Concrete and Construction Engineering, v. 30, no. 2, Feb. 1935. p. 126-135. (figures, references)

Types of vibration and general principles. Machinery vibrations and isolating materials. Methods of application. Impact machines. Traffic vibrations and noise.

Katel, J. L'Influence de Trépidations de diverses Sources exterieur sur la Stabilité des Bâtiments à la Santé publique. Science et Industrie, v. 19, no. 29, May 1935. p. 178-185. (figures, references)

Results of German investigations. Measurement of vibrations. Proposed scale of vibration intensities. Study of the effect of vibrations from various outside sources on the stability of buildings and on the health of their inhabitants.

Meister, F. J. Die Empfindlichkeit des Menschen gegen Erschütterungen. Forschung aus dem Gebiete des Ingenieurwesens, v. 6, no. 3, May-June 1935. p. 116-120. (figures, tables, references)

Sensitivity of the human body to vibrations. Method and results of tests and conclusions arrived at. Proposed vibration scale.

Mori, T. Vibrations of Bofie Railway Cars. Soc. Mech. Engrs. (Japan)-Trans., v. 1, no. 2, May 1935. p. 153-163. (In Japanese with a brief English abstract)

Study of natural and forced vibrations of passenger cars in which damping friction is first assumed to be negligible.

Pöschl, T. Über die Eigenschwingungen von Fachwerken mit Massen in den Knotenpunkten. Stahlbau (Suppl. to Bautechnik), v. 8, no. 6, March 15, 1935. p. 41-43. (figures, equations, references)

Theoretical, mathematical analysis of vibrations of framed structures with loads concentrated at the joints.

Morris, J. Critical Speeds of a Wind Tunnel Fan Shaft. Roy. Aero. Soc.-Jl., v. 40, no. 307, July 1936. p. 557-560. (figure)

In design of fan drive, regard should be had for possible critical or resonant speeds which may result in failure of the system. The possibility of such resonance in the system is considered mathematically. Conclusions.

# PATENTS RELATING TO VIBRATION

## UNITED STATES

1740362 Propeller-Shaft Support. Issued to O. Mader, assignor to H. Junkers, Dessau, Germany, June 30, 1928.

In order to reduce vibration of the propeller shaft, bearings are provided designed to permit the shaft to adjust itself until its center of gravity lies in the axis of rotation. For this purpose the shaft is connected to the driving mechanism at its inner end by a universal joint which permits the shaft to pivot in any direction, and near its outer end, close to the propeller, there is provided a spring-supported bearing intended to permit radial displacement to the shaft.

1773481 Airplane Construction (Engine Bed Mounting; Vibration Absorber). Issued to Anthony H. G. Fokker, assignor to the Atlantic Aircraft Corp., Aug. 19, 1930.

Relates to a resilient suspension for the engine of an aeroplane so that vibrations will not be transmitted to the fuselage framework or to the radiators, oil tanks, etc. The supporting lug of the motor is secured to a rectangular block of elastic material such as rubber by a bolt passing through the vertical centerline of the block between washers or plates. The bolts pass through the resilient block at either side of the engine bolt securing same to the longitudinal frame member. A retainer is provided to prevent distortion of the elastic block due to the weight of the engine and frame.

1778503 Vibration-Dampening Mounting. Issued to Hugh C. Lord, Oct. 14, 1930.

In a vibration damping mounting, the combination of a supporting member and a supported member, one of said members being provided with vibration producing means, and a mounting of resilient rubber bonded to one of said members and disposed in thrust resisting relation with the other member, said mounting including a body of rubber projecting from the member to which the mounting is bonded and so disposed as to receive the thrust through shear stress, the shear being in the direction of the vibratory thrust to be absorbed by the mounting.

1950350 Vibration Dampener. Issued to Joseph J. Boland, assignor to the Aeromarine Plane and Motor Co., N. Y., March 6, 1934.

Combination with a machine having a rotatable member tending to generate unbalanced inertia forces of varying value, of a means tending to modify said unbalanced forces to a constant value, said means including a single element of unbalanced proportions mounted on one side of said rotatable member for rotation relative thereto, and means engaging said element to cause it to planetize about the axis of said rotatable member.

1980185 Torsional Vibration Damper. Issued to Roland Chilton, assignor to the Wright Aeronautical Corp., Nov. 13, 1934.

A clutch comprising a driving member; a driven member; a hub secured to one of said members; a disc secured to the other said member, and surrounding said hub; means for providing a positive drive in one direction while allowing slippage in the opposite direction, said last named means comprising projections attached to the hub and contacting at their outer ends with the disc, said disc being disposed on one side of and in constant frictional contact with said projections; a flange attached to the disc and extending inward therefrom on the opposite side of the projections; and means for resiliently pressing the flange into frictional engagement with said projections, whereby an overload friction clutch is provided in addition to the uni-directional drive.

2037698 Vibration Recording Instrument. Issued to Victor E. Carbonara, assignor to the Bendix Aviation Corp., April 21, 1936.

In a vibration recording instrument of the type including a casing having a mass mounted for universal relative movement therein, a reflecting member carried by said mass, light projecting means secured in said casing for projecting a beam of light into said reflecting member whereby said beam is vibrated by relative movement between said member and said casing when the latter is mounted on a member the vibrations of which are to be recorded and additional reflecting means secured in said casing for further reflecting said beam, the combination of a rotatable reflecting member interposed between the reflecting member carried by the mass and the reflecting means secured in the casing, means for rotating said rotatable reflecting member whereby said vibrating beam is further reflected and has an angular movement imparted thereto, and a relatively stationary light-sensitive film in said casing for receiving said angularly movable vibrating beam thereon whereby a photographic record of the vibrations of the vibrating member is produced.

## GREAT BRITAIN

329436 Improvements in or Relating to Power Transmission of Motor Vehicles. Issued to J. Atkinson, assignor to the Leyland Motors Co., Lancashire, March 18, 1929.

To overcome vibration and noise which, due to well-known causes, occur in the transmission shaft, a friction damper is arranged immediately behind the gear box or in another suitable position. In the main, the vibration damper is comprised of a rotating mass composed of two heavy rings which are pressed apart by springs against two flanges. These flanges are bolted to a spider which is mounted on the end of the gear box final driving shaft. Friction linings are interposed between the rings and the adjacent flanges, while a ring, composed of rubber or similar material, closes the gap between the two rings.

336795 Improvements in or Relating to Apparatus for Indicating or Recording Vibrations of Rotating Shafts or Members. Issued to I. J. Gerard, B. C. Carter, and H. C. Mansell, Oct. 17, 1929.

Consists of dynamometers, rotary transmission, with recording apparatus. Comprises a construction of the type in which the torsional vibrations of a shaft are used to tilt a mirror, reflecting a beam of light, on to a screen or photographic plate. Two figures illustrate the apparatus.

358789 Improvements in Driving Mechanism for Aircraft Propellers. Issued to H. Junkers, Dec. 2, 1930.

Mechanism for the transmission of energy from engines or motors with periodically fluctuating torque to aircraft propellers, includes an elastic member interposed in the revolving transmission mechanism and so dimensioned as to prevent resonance of the specific frequency of revolving parts during fluctuations in engine torque in the range of higher engine speeds.

382787 Improvements in Devices for Reducing Torsional Oscillations in Crankshafts. Issued to R. R. R. Sarazin, June 30, 1931.

To reduce the torsional oscillation in crankshafts, a fly-wheel is fitted with movable masses in a hollow drum integral with the shaft. The weights are displaced against centrifugal force by the recess in the drum, which engage rollers on projecting heads forming part of the movable masses. The difference in radius between the recesses and the projecting heads represents the radius along which the masses are displayed.

383689 Improvements in Shaft Dampers for Use with Engines. Issued to Sir F. H. Royce, Sept. 22, 1931.

A dynamic balancer comprised of a drum mounted around a shaft concentrically and coupled thereto by means of resilient shaft. Friction means are provided, reacting between the shaft and the drum, and being so disposed that when subjected to centrifugal force by rotation of the shaft and drum, they urge the friction means into engagement. Springs bearing on the weights also urge the shoes into engagement with the interior of the drum.

392949 Improvements in Engine Mountings. Issued to R. S. Trott, 704 Equitable Building, Denver, Colorado, U.S.A., Nov. 16, 1931.

Mounting is intended to smooth out the variable torque of a petrol engine and so to prevent vibration occurring. Although intended for automobiles, drawing is given showing the application of the mounting to an aero engine.

436981 Improvements Relating to Devices for Damping the Oscillation of the Revolving Wings or Blades of Aircraft. Issued to D. Kay and J. W. Dyer, Kay Gyroplane, Ltd., 18 Atholl Crescent, Edinburgh, Scotland, June 26, 1934.

In the case of rotors with blades hinged on the two planes, it is stated that when movement is allowed in the plane of the blades, rapid oscillations have been found to occur. It is therefore proposed to arrange in the wings, a weight capable of movement in the chord direction, which act by their inertia so as to oppose the rebound of the blade. Damping devices may, in addition, be fitted to the hub of the rotor.

461353 Oscillation Vibration Damper for the Mechanism Controlling the Movable Flaps of Aeroplanes. Issued to L.

Bechereau, May 24, 1935.

This apparatus is intended to absorb vibrations in the control mechanism of aeroplanes by means of shock absorbers in the control mechanism. The method consists in interposing in the steerage control a rectilinear vibration damping apparatus of the piston and cylinder type, in which the piston rod extends on opposite sides of the piston through the braking cylinder and which exerts a symmetrical action in both directions, the resistance of this apparatus depending solely on the frequency of the oscillations of the flaps.

463008 Improvements in Means for Absorbing Vibrations in Aircraft. Issued to Short Bros., Rochester and Bedford, Ltd., and G. I. Robinson, both of Seaplane Works, Rochester, Kent, Feb. 11, 1936.

The device is described as used for a wing tip float which is supported by nearly vertical struts cross-braced by two wires, and the device is inserted at the crossing of the wires. As variable loads affect the device, shock is absorbed by means of rubber blocks.

## BOOKS ON GENERAL VIBRATION PROBLEMS

Frith, J. and Buckingham, F. Vibration in Engineering. London: Macdonald & Evans, 1924. 123 p. (figures, tables, bibliography)

This book deals at length with free, forced and damped vibrations and presents mathematical aspects of such motions in some detail. Simple vibrations dealt with only, and a single practical case of vibrations of machinery shafts. Valuable because of effective presentation of essential line of mathematical attack. A few hints on factors favoring or opposing transmission of vibrations.

Timoshenko, S. P. and Lessells, J. M. Applied Elasticity. E. Pittsburgh, Pa.: Westinghouse Technical Night School Press, 1925. 1st Edition. 544 p.

Two engine problems that are receiving attention in automobile and aeronautic engines are those of vibration and of weight reduction. First section is analytical, containing some advanced chapters devoted to the strength of materials. An entire chapter is devoted to problems on dynamical stresses produced in moving machine parts by inertia and vibrations. Review of the general theory of vibration of elastic systems; several practical problems discussed, such as critical speeds of shafts, torsional vibrations of shafts and stresses produced during impact. Second section gives information on the mechanical properties of materials.

Crandall, I. B. Theory of Vibrating Systems and Sound. N.Y.: D. van Nostrand Co., 1926. 272 p. (figures)

The purpose of this book is to give in modern terms, a treatment of the basic theory of vibrating systems and sound, and to show how it has been applied to current problems. Specifically, the book covers simple vibrating systems; general theory of vibrating systems; resonators and filters; propagation of sound; radiation and transmission problems; the acoustics of closed spaces; absorption, reflection and reverberation.

Zipperer, L. Technische Schwingungslehre. Vol. 2. Berlin and Leipzig: W. de Gruyter & Co., 1927. 124 p. (figures, bibliography)

After the discussion of vibration in general, given in the first volume of the work, the second proceeds to discuss the individual methods for calculating the specific rate of torsional vibration in shafts with various numbers of disk flywheels. The method of calculating transverse vibrations is then given. Attention is then turned to experimental methods and to methods for avoiding vibration.

Geiger, J. Mechanische Schwingungen und ihre Messung. Berlin: J. Springer, 1927. 305 p. (figures)

Theory of various types of vibratory systems, natural and forced vibrations, multi-mass systems, damping. Vibrations of internal combustion engine shafts, equivalent masses and equivalent elasticities. Theories, descriptions and duplications, and applications of vibration measuring instruments.

Purday, H. F. P. Diesel Engine Design. London: Constable & Co., Ltd., 1928. 360 p. (figures, tables)

Book includes a chapter dealing with some recent developments in double-acting engines and supercharging. More complete account given of the twisting effects in crankshafts. Previous treatment of torsional vibrations has been amplified.

Steuding, H. Messung mechanischer Schwingungen. Berlin: V.D.I.-Verlag, 1928. 500 p. (figures, tables, bibliography)

Critical investigation of methods and apparatus for measuring mechanical vibration. Classification of methods and apparatus from viewpoints of physical principles and applications. Consideration of seismometry. General theory of apparatus for measuring vibrations and criteria established for judging it. Fields considered are biology, physiology, varying stresses in structures and machines, acoustics, periodic vibrations in machinery and indicators for engines. Valuable bibliography of over 1400 references.

Timoshenko, S. P. Vibration Problems in Engineering. N.Y.: D. van Nostrand Co., 1928. 351 p. (figures)

Exposition of the fundamentals of the theory of vibrations with special reference to the application of the theory to such practical problems as the balancing of machines, the vibrations in turbines and in railroad track and bridges, and in the whirling of rotating shafts. The topics discussed include harmonic and non-harmonic vibrations in a system with several degrees of freedom, and in elastic bodies. A chapter on measuring instruments is included. Applications to various engineering problems developed.

Dalby, W. E. The Balancing of Engines. N.Y.: Longmans, Green & Co., 1929. 321 p. (figures, tables)

Thorough mathematical discussion of the theory of balancing, and calculation and lay-out on drafting board; methods of accounting for unbalance, couples, turning moment, vibration and other factors. Chapter on vibration in railroad bridges set up by unbalance in locomotives.

Föppl, O., Becker, E. and v. Heydekampf, G. Die Dauerprüfung der Werkstoffe. Berlin: J. Springer, 1929. 124 p. (figures, references)

Discussion of apparatus and methods for determining the fatigue of metals subjected to vibration. A variety of testing machines is described, their use explained, and methods of testing given, together with some results.

Morris, J. The Strength of Shafts in Vibration. London: C. Lockwood & Sons, 1929. 189 p. (figures, tables)

General mathematical investigation of vibration in shafts. Based on the assumption that the shaft, in effect, is made up of a series of infinitely thin discs threaded on the axis of the shaft. This book deals with the elementary principles of the bending of rods and Lord Rayleigh's reciprocal relations and their application; the vibration of a system of concentrated load on a horizontally supported shaft; the vibration of continuously loaded cantilevers; torsion problems and the effect of gears, etc. Examples are worked out, more on the academic side than on the practical.

Ramsey, A. S. Dynamics. Cambridge: University Press, 1929. 259 p. (figures)

Included are two chapters devoted to harmonic motion and its applications, and to the problem of small oscillations and the stability of motion.

Streeter, R. L. and Lichty, L. C. Internal-Combustion Engines, Theory and Design. N.Y. and London: McGraw Hill Book Co., 1929. 3rd Edition. 445 p. (figures)

Underlying principles of internal-combustion engines. Included is a chapter on vibrations and engine balance.

Wilson, W. K. The Balancing of Oil Engines. London: C. Griffin & Co.; Philadelphia: J. B. Lippincott Co., 1929. 279 p. (figures, tables)

A presentation of principles and practice, based upon long experience in the design and production of internal combustion engines. The author first surveys the principles and shows how they can be used to calculate unbalanced forces and couples, after which he analyzes engines of from one to eight cylinders in a series of chapters. Graphical methods, general design and the design of vibrationless foundations are considered. The book is suited to practical use in the designing office.

Lehr, E. Schwingungstechnik. Vol. 1; Grundlagen. Die Eigenschwingungen eingliedriger Systeme. Berlin: J. Springer, 1930. 295 p. (figures, tables, bibliography)

A simple text with numerous examples of vibration problems worked out, such as the calculation of the critical velocity of a 6-cylinder airplane motor.

Wedemeyer, E. A. Automobilschwingungslehre. Braunschweig: F. Vieweg & Sons, 1930. 186 p. (figures) From the collection "Sammlung Vieweg", Nos. 103-104.

This book is for the layman. It deals with the different types of vibrations of automobile and aircraft engines, chassis vibrations, damping, noise, shimmy and the influence of the road on the automobile.

Wood, A. B. Textbook of Sound. N.Y.: Macmillan Co., 1930. 519 p. (figures, tables, bibliography)

Treats vibrations of all frequencies, audible or otherwise. Side by side with the earlier work of Rayleigh and Lamb, the author presents the new methods of investigation and the new theoretical developments that have arisen and also calls attention to the many technical applications of today. He has produced an admirable textbook for university students, and also a convenient reference book for physicists and engineers.

Föppl, O. Grundzeuge der technischen Schwingungslehre. Berlin: J. Springer, 1931. 212 p. (figures, tables)

Concise treatise on the theory of vibration and its applications in engineering. The effects of vibration upon structural materials, methods of calculating frequencies, damping devices, the prevention of vibration in reciprocating machines, and similar topics are discussed.

Slocum, S. E. Noise and Vibration Engineering. N.Y.: D. van Nostrand Co., 1931. 171 p. (figures, bibliography)

Book points out the various features of vibration. Includes a chapter in which tests of vibration dampers are described and typical results, but incomplete tables of characteristics, are presented.

Younger, J. E. and Woods, B. M. Dynamics of Airplanes and Airplane Structures. London: Chapman & Hall; N.Y.: J. Wiley & Sons, Inc., 1931. 203 p. (figures, bibliography)

Book includes examinations of structural questions, particularly of flutter, torsion of propeller blades, engine vibrations, etc. Includes mathematical preparations beyond second-year calculus and elementary differential equations. Latter part of book bears on the method of attack upon specifically aeronautical problems.

Barkhausen, H. Einführung in die Schwingungslehre nebst Anwendung auf mechanischen und electrischen Schwingungen. Leipzig: S. Hirzel, 1932. 125 p. (figures)

Elementary treatise on the theory of vibrations. The book is divided into three parts. (1) Sinusoidal oscillations: elementary characteristics of oscillations, self-induced oscillations, electrical oscillations, composition of sinusoidal oscillations. (2) Oscillatory systems: systems at two degrees of freedom, systems at infinite degrees of freedom, mechanical oscillations, electrical oscillations, periods of the oscillations most frequently encountered. (3) Origin of oscillations: damped oscillations and continuous oscillations.

Hohenemser, K. Die Methoden zur Angenäherten Lösung von Eigenwertproblemen in den Elastokinetik. Berlin: J. Springer, 1932. 89 p. (figures)

Discussion of the general methods of linear integral equations of the second kind and their application to the vibration of elastic bodies. Important special problems taken up, such as vibration in rods, plates and frameworks, and critical speed of shafts. This is intended to give engineers a survey of general methods for solving vibration problems and to provide mathematicians with an account of the uses of the method in practice.

Kimball, A. L. Vibration Prevention in Engineering. N.Y.: J. Wiley & Sons, Inc.; London: Chapman & Hall, Ltd., 1932. 145 p. (figures, tables, references)

Reference work for engineers on noise and vibration in engineering work of the General Electric Co. Scope of volume includes all material necessary for handling effectively any usual vibration problem.

Reid, E. G. Applied Wing Theory. N.Y. and London: McGraw-Hill Book Co., Inc., 1932. 1st Edition. 231 p. (figures, bibliography)

Collection of technical presentation of Prandtl, Lanchester, Kutta, Jonkowski, Munk, Glauert, et al., coordinated and brought up to date. It is presented in elementary and concise form. Explanatory and corollary material from the author's own experience.

Root, R. E. Dynamics of Engine and Shaft. N.Y.: J. Wiley & Sons, Inc.; London: Chapman & Hall, Ltd., 1932. 184 p. (figures)

Presentation of methods for evaluating the forces that operate in a reciprocating engine, to trace their effects in turning moment on the shaft and in bearing pressures, and to reveal their significance in relation to vibrations. Book also treats of torsional and transverse vibrations of elastic systems and discusses critical speeds. In the last three chapters dealing with vibrations, use is made of linear differential equations and of the theory of elasticity.

Heldt, P. M. Automotive Engines - Design, Production, Tests. N.Y.. P. M. Heldt, Nyack, 1933. 8th Edition. 598 p. (figures)

Outstanding feature of the latest volume is a new chapter on torsional vibration and vibration dampers in which a method is developed for predetermining the critical speeds of torsional vibration of engines from design characteristics. This predetermination of critical speeds is of great importance for aircraft and marine engines which are held to a definite speed by the propeller load.

Hohenemser, K. and Prager, W. Dynamik der Stabwerke. Berlin: J. Springer, 1933. 367 p. (figures, tables, bibliography)

Systematic treatment given of the problem of the free and forced vibrations of a framework made up of uniform bars, and for similar problems, which do not lend themselves to exact treatment. Approximate methods based on the use of Rayleigh's principle offered. Section 1 gives a brief account of the kinematics of simple harmonic motion and the free and forced vibrations of a system of one degree of freedom. Section 2 deals with the problem of a beam whose mass is assumed to be concentrated at three points. Section 3 deals with the free vibrations of a framework. Section 4 deals with forced vibrations. Section 5 considers the effect of sudden application or removal of a load.

Temple, G. F. J. and Bickley, W. G. Rayleigh's Principle and its Applications to Engineering. London: Oxford Univ. Press, 1933. 156 p. (figures, tables)

Purpose of this volume is to familiarize engineers with the utility of Rayleigh's energy method for the rapid, direct calculation of the approximate values of critical loads and speeds. The method is developed in such a way as to furnish both upper and lower estimates of the true value required, so that it enables critical loads and frequencies to be determined with close, known degrees of approximation.

Den Hartog, J. P. Mechanical Vibration. N.Y. and London: McGraw Hill Book Co., Inc., 1934. 390 p. (figures)

This book is intended for use as a textbook, and also aims to meet the needs of practicing engineers. Theory is presented in understandable form and its practical applications to water wheels, steam turbines, automobiles, airplanes, Diesel engines and electric machinery are discussed in detail.

Inglis, C. E. A Mathematical Treatise on Vibrations in Railway Bridges. Cambridge: University Press, 1934. 203 p. (figures, tables)

Theoretical work consisting of the development of a satisfactory mathematical method for calculating bridge vibrations under various kinds of acting forces. Three principal causes of dynamical effect of moving loads on a bridge, this book deals principally with "hammer-blows" due to balance-weights which are attached to the driving-wheels of a locomotive. Complete treatise. Theoretical solution of a series of important vibration problems and also some approximate solutions.

Judge, A. W. Automobile and Aircraft Engine. London: I. Pitman & Sons, Ltd., 1934. 3rd Edition. 890 p. (figures, tables)

Chapter on "Engine Mechanics" contains a considerable section on crankshaft torsional vibration.

Lehr, E. Schwingungstechnik. Vol. 2; Schwingungen eingliedriger Systeme mit stetiger Energiezufuhr. Berlin: J. Springer, 1934. 373 p. (figures, tables, bibliography)

This is the second installment of a comprehensive tretise upon vibration in which the subject is discussed from the viewpoint of the engineer and machine builder, and the problems discussed are treated with sufficient fullness to equip the reader for the solution of questions arising in practice. Discussion of forced vibrations, resonance and pseudo-harmonic vibrations. A field of great practical importance is discussed in a very practical manner.

Späth, W. Theorie und Praxis der Schwingungsprüfmaschinen. Berlin: J. Springer, 1934. 98 p. (figures, tables, bibliography)

This book is intended as an exhaustive yet brief account of the various questions connected with the carrying out of vibration tests and evaluation of the results. First section is devoted to theoretical considerations of vibration, machines for testing, methods of measuring vibration, and of evaluating resonance curves. Second part discusses practical uses of vibration testing, including measurements of bridges, ships, soils, buildings, vehicles, and machinery.

Tuplin, W. A. Torsional Vibration. N.Y.: J. Wiley & Sons, Inc.; London: Chapman & Hall, Ltd., 1934. 320 p. (figures, tables, bibliography)

Fundamentals of vibration theory. Procedure to be followed in actual calculations shown in detail. New conception associated with the term "torque function". Certain methods derived from this, which have advantages over conventional ones.

Cole, E. B. Theory of Vibrations for Engineers. London: Crosby, Lockwood & Sons, 1935. 263 p. (figures, tables, bibliography)

This book aims to bridge the gap between elementary textbook treatment on the elasticity of materials and the higher studies which call for mathematical attainments. Intermediate course, in which physical meaning of mathematical equations is stressed and attention given to methods of practical utility to designers of high-speed machinery.

Karas, K. Die Kritischen Drehzahlen wichtiger Rotorformen. Vienna: J. Springer, 1935. 134 p. (figures, tables)

Aim of this book is to derive methods and formulae which enable the designer to calculate the critical speeds of rotors with more exactness than is obtainable by the usual graphical methods. Special discussion of the question of steam-turbine rotors. Methods and formulae applicable rapidly and safely.

Wilson, W. K. Practical Solution of Torsional Vibration Problems. N.Y.: J. Wiley & Sons, Inc.; London: Chapman & Hall, Ltd., 1935. 438 p. (figures, tables, bibliography)

The principles and computation details given of the torsional vibration problem in a manner suitable for every day reference. The selection and arrangement of the subject matter are based on several years of practical experience in carrying out torsional vibration investigations on many types of installation. The methods which are developed have been found reliable in practice.

Younger, J. E., Rice, R. H. and Ward, N. F. Structural Design of Metal Airplanes. N.Y. and London: McGraw Hill Book Co., Inc., 1935. 344 p. (figures, references)

Fundamental principles and methods involved in the metal construction of airplanes. Section I - Design requirements. Section II - Materials available for construction. Section III - Basic structural analysis. Applications of mechanics to design. Section IV - Special problems pertinent to design and construction of metal airplanes with special attention to cantilever wings and wing flutter. Book is suited for text.

Föppl, O. Aufschaukelung und Dämpfung von Schwingungen. Vol. 2; Grundlage der Technischen Schwingungslehre. Berlin: J. Springer, 1936. 121 p. (figures)

This book discusses a number of questions which have acquired technical importance in recent years, such as, balancing of crankshafts, artificial damping of vibrations, prevention of resonance and vibration of ships.

Southwell, R. V. An Introduction to the Theory of Elasticity for Engineers and Physicists. Oxford: Clarendon Press, 1936. 500 p. (figures, tables, bibliography)

Theory of elasticity is simply explained and its importance in working theories of stress, strain and vibration. In chapter VI, introduction is made to the vibration theory, and application of approximate theories of bending and torsion to plates, springs and crankshafts. Chapter XIV is concerned with vibrations and Rayleigh's principle. Other chapters on analysis of stress in three dimensions and equations, general analysis of strain, their relation by generalized statement of Hook's law, and general equations of elasticity. Practical problems given.

Purday, H. F. P. Diesel Engine Design. London: Constable & Co., Ltd., 1937. 4th Edition. 520 p. (figures, tables, bibliography)

The tendency towards higher piston speeds has increased the importance of vibration problems. Accordingly, new chapters have been added in this edition on balancing, torsional and transverse vibration and noise.

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